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Jurassic Nassellariina (Radiolaria) from North American Geologic Terranes

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by

E. A. Pessagno, Jr., P. A. Whalen, and K.-Y. Yeh

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JURASSIC NASSELLARIINA (RADIOLARIA) FROM NORTH AMERICAN GEOLOGIC TERRANES[1]

By

E. A. Pessagno, Jr.,[2] Patricia A. Whalen,[2] and Kuei-Yu Yeh[3]

ABSTRACT

Much of the western part of the Cordilleran Region of North America is characterized by geologic terranes which originated at low latitudes and were displaced to higher latitudes during the Late Paleozoic and Mesozoic. Many of these terranes such as the Wrangellia terrane have been displaced hundreds or even thousands of kilometers from lower, near-equatorial latitudes to their present positions.

The magnitude of the tectonic complexity of the western Cordilleran Region is immense. Obviously, paleontologists must consider the displaced terrane problem in their attempts to compile meaningful biostratigraphic zonations and zoogeographic reconstructions for the Mesozoic of this region and indeed, the entire Circum-Pacific margin.

The potential utility of Radiolaria in Mesozoic biostratigraphic and paleo-oceanographic studies and in geology in general is enormous. Radiolarian zonal schemes now rival those of the ammonites in parts of the Jurassic and Cretaceous. Furthermore, even though the study of Jurassic Radiolaria is still in its infancy, it is now apparent that at least for the Middle and Upper Jurassic, Radiolaria can be utilized to differentiate the Tethyan Realm from the Boreal Realm and to subdivide each of these faunal realms into provinces. On the basis of simple criteria we subdivide the Tethyan Realm into: (1) A Central Tethyan Province characterized by the presence of *Ristola* Pessagno and Whalen, 1982, the absence of *Parvicingula* Pessagno, 1977a, and high pantanelliid diversity; and (2) a Northern Tethyan Province, characterized by common *Parvicingula* and high pantanelliid diversity. The radiolarian assemblage of the Boreal Realm during the Middle and Late Jurassic is characterized by the presence of abundant *Parvicingula* and by low pantanelliid diversity. The Boreal Realm is in turn subdivided into a Southern Boreal Province where pantanelliids still persist and a Northern Boreal Province where pantanelliids appear to be absent.

Using these simple criteria together with megafossil and paleomagnetic data (where available), we have been able to chart the course of various displaced terranes from low to higher latitudes during the course of Jurassic time. In the terranes of the Blue Mountains Province of eastern Oregon, both the radiolarian and ammonite assemblages reflect a change from Tethyan (Northern Tethyan Province) to Boreal (Southern Boreal Province) during the late Bathonian/Callovian. The first or final appearances of many taxa occurring in the late Bajocian—Bathonian—Callovian may, in fact, be paleolatitudinally controlled and may not reflect their total range in Boreal or Tethyan strata.

Most of the taxa included in the *Systematic Paleontology* herein are described from geologic terranes that have been displaced from low (Tethyan) latitudes to higher (Boreal) latitudes during Jurassic times. Two new genera (*Farcus,* n. gen., and *Rolumbus,* n. gen.) and thirty-four new species (*Farcus asperoensis,* n. sp., *F. graylockensis,* n. sp., *Rolumbus gastili,* n. sp., *R. hamiltoni,* n. sp., *R. halseyensis,* n. sp., *R. mirus,* n. sp., *R. venustus,* n. sp., *Hilarisirex inflatus,* n. sp., *H. oregonensis,* n. sp., *Jacus reiferensis,* n. sp., *J.*(?) *sandspitensis,* n. sp., *Napora antelopensis,* n. sp., *N. baumgartneri,* n. sp., *N. bearensis,* n. sp., *N. bona,* n. sp., *N. boneti,* n. sp., *N. browni,* n. sp., *N. burckhardti,* n. sp., *N. cerromesaensis,* n. sp., *N. cosmica,* n. sp., *N. fructuosa,* n. sp., *N.* (?) *graybayensis,* n. sp., *N. heimi,* n. sp., *N. horrida,* n. sp., *N. insolita,* n. sp., *N. izeensis,* n. sp., *N. maritima,* n. sp., *N. mitrata,* n. sp., *N. moctezumaensis,* n. sp., *N. morganensis,* n. sp., *N. opaca,* n. sp., *N. tumultuosa,* n. sp., *N. turgida,* n. sp., and *N. vegaensis,* n. sp.) have been described among the nassellarian families Farcidae, n. fam., Hilarisiregidae Takemura and Nakaseko, 1982, and Ultranaporidae Pessagno, 1977b. In an effort to formulate a more phylogenetic classification for these families and their included genera, we have stressed test construction as the primary basis for their definition.

Many of the species and genera figured in this report are distinctive and short ranging; as a result, they should prove useful in compiling a detailed radiolarian zonation for the Jurassic. Range zone data are presented for all taxa. Where known, the distribution of taxa within the Tethyan and Boreal realms is indicated in the text and text-figures.

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INTRODUCTION

The study of Jurassic Radiolaria is still in its infancy. Except for a few reports at the turn of the century by workers such as Rüst (1885, 1898), Parona (1890), and Vinassa de Regny (1899), no other comprehensive studies dealing with Jurassic Radiolaria were published until the 1970's (*e.g.*, Foreman, 1973; Pessagno, 1977a). Investigations completed (Pessagno and Blome, 1980; Baumgartner, 1980a; Baumgartner, De Wever, and Kocher, 1980; Pessagno and Poisson, 1981; Pessagno and Whalen, 1982; Pessagno and Blome, 1982; De Wever, 1982; Baumgartner, 1984; Blome, 1984b) and in progress indicate that the Jurassic assemblage from both the Tethyan Realm and the southern part of the Boreal Realm is quite diversified. It is not uncommon to find as many as 60 to 150 species-level taxa in well-preserved assemblages. In spite of the recent surge of investigations, approximately 85 percent of the total Jurassic assemblage remains undescribed.

The potential of these planktonic microfossils for Mesozoic stratigraphy and for geology in general is immense. Radiolarian zonal schemes now being compiled by Baumgartner (1984) and Pessagno, Blome, Carter, MacLeod, Whalen, and Yeh [in press] rival those of the ammonite workers in many parts of the Jurassic succession. For example, in the Middle Jurassic succession of east-central Oregon (Suplee–Izee Area, John Day Inlier) Smith (1980, p. 1606, fig. 4) included Bajocian strata in five ammonite zones; Pessagno, Blome, Carter, MacLeod, Whalen, and Yeh [in press] divide the Bajocian into four radiolarian zones. As more stratigraphically-useful taxa are described, it is likely that the resolution of the radiolarian zonation for the Bajocian will be even further enhanced.

In compiling a zonal scheme for the Jurassic we are attempting to calibrate our radiolarian biostratigraphy with that of the ammonites and other well-studied fossil groups (*e.g.*, the calpionellids; see Pessagno, Blome, and Longoria, 1984). We are defining radiolarian zonal units using taxa with tests sufficiently sturdy to be preserved not only in residues extracted from limestones, but also in residues extracted from cherts and shales. Furthermore, where possible, we define zonal units utilizing taxa that bridge the Boreal and Tethyan realms. A zonal scheme so contrived should prove invaluable in interpreting the stratigraphy and ultimately the complex structure of radiolarian-chert-bearing terranes in western North America.

In addition to their use in biostratigraphic studies it is now obvious that Jurassic Radiolaria can be useful in delimiting faunal realms, or in some cases, provinces within realms. For example, for the Middle and Late Jurassic, it is possible to differentiate a Central Tethyan Province from a Northern Tethyan Province and to delimit the boundary between the Tethyan and Boreal realms. In spite of the fact that the study of Jurassic Radiolaria and indeed all Mesozoic Radiolaria is still in its infancy, it is apparent that this group of microfossils offers great potential in paleolatitudinal studies. It is also apparent that the radiolarian faunal data, together with those of other fossil groups, should be useful in helping tectonocists recognize displaced terranes and in charting the courses of such terranes throughout the course of the Mesozoic (see *Tectonostratigraphy*).

The present report focuses on three important family groups: the Farcidae, n. fam., the Hilarisiregidae Takemura and Nakaseko, 1982, and the Ultranaporidae Pessagno, 1977b. The first two families are restricted to the Jurassic whereas the range of the third family extends into the Cretaceous. Many species-level taxa of all three families are short-ranging and distinctive and should be useful in formulating a zonation for the

North American Jurassic. Samples that we have studied for the purpose of this project come from east-central Oregon (Suplee–Izee Area, John Day Inlier), the Queen Charlotte Islands, east-central Mexico, and Baja California Sur.

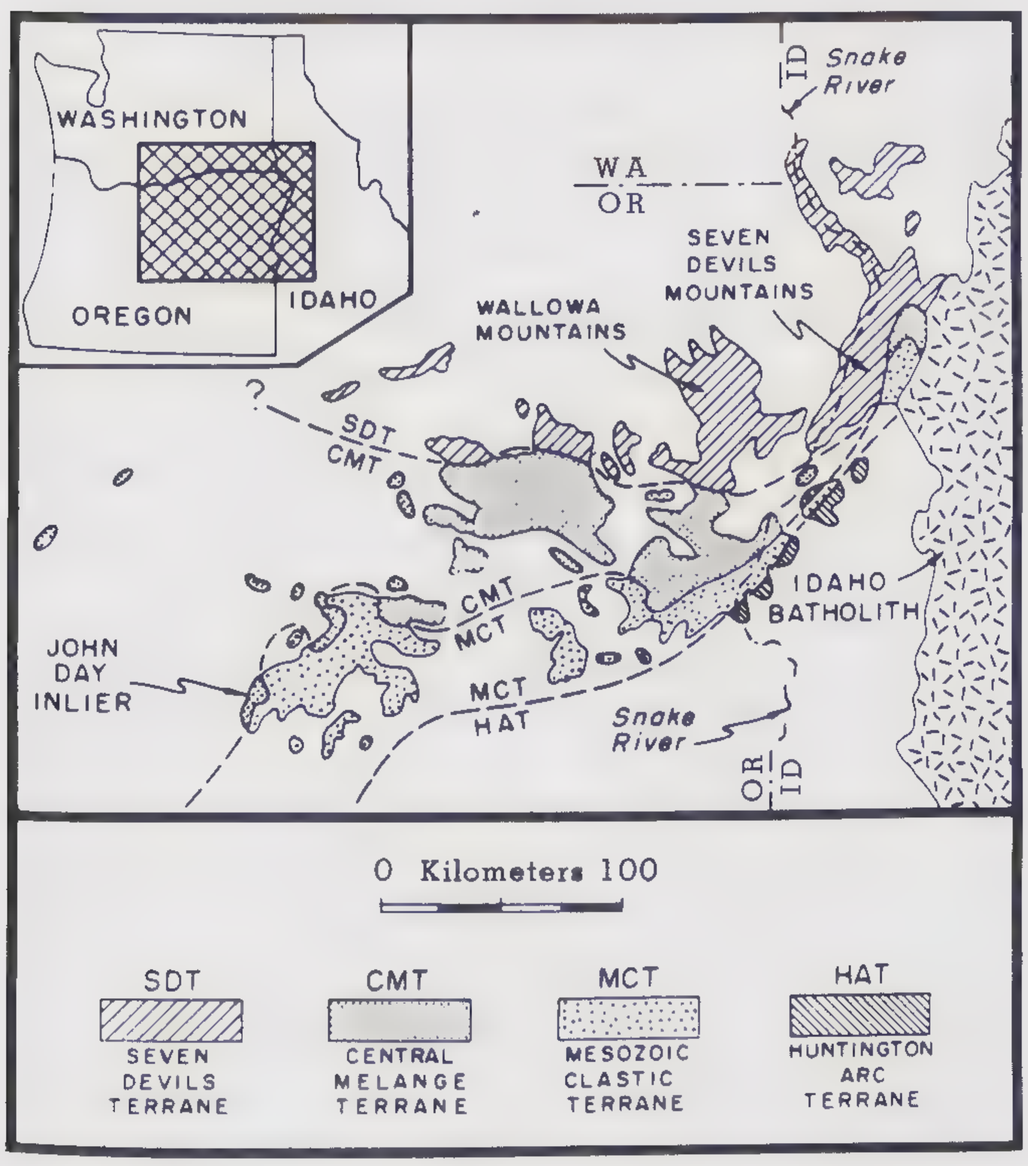
TECTONOSTRATIGRAPHY AND THE FAUNAL MOSAIC OF THE WESTERN CORDILLERAN REGION

The western part of the Cordilleran Region is a collage of displaced terranes that have been accreted to the craton during the Paleozoic and Mesozoic. Many large terranes (*e.g.,* Wrangellia) have been displaced hundreds or even thousands of kilometers from their point of origin (Jones, Silberling, and Hillhouse, 1977). Pessagno and Blome (1986) suggested that the driving mechanisms for such large scale displacements are megashears such as those that crosscut Mexico in a northwest-southeast direction (Longoria, 1984, 1985). Moreover, they suggested that many of the larger terranes such as Wrangellia, the Blue Mountains terrane, and the Sierran terranes originated at low latitudes and gradually moved northward along megashear systems during the course of the Mesozoic. The faunal record of the aforementioned terranes is remarkably similar. It is noteworthy that all of these terranes display dominantly Tethyan faunas at least until the end of the Bajocian. By the late Bathonian or Callovian, Boreal faunas predominate. As indicated by Pessagno and Blome (1986), the shift of these terranes to higher latitudes is coincident with the opening of the Gulf of Mexico during the late Bathonian or Callovian.

Triassic, Jurassic, and Lower Cretaceous red, manganiferous ribbon cherts, which occur in ophiolites and in subduction complexes from Baja California to Alaska, all contain Tethyan (dominantly Central Tethyan; see below) radiolarian assemblages (Pessagno, Blome, and Longoria, 1984, p. 20). In the melange of the Franciscan Complex (California Coast Ranges) or the Pacific Rim Complex (Vancouver Island), it is not uncommon to find masses of red ribbon chert containing Central Tethyan Radiolaria adjacent to blocks of flyschoid sandstone and shale containing *Buchia* Rouillier, 1845, and Boreal Radiolaria. The spectrum of complexity resulting from latitudinally-displaced terranes in the western part of the Cordilleran Region is thus immense. Obviously, it makes biostratigraphic analysis difficult and broad-scale zoogeographic reconstructions impossible.

Before the introduction of the displaced-terrane hypothesis by Jones, Silberling, and Hillhouse (1977), most attempts to discuss the Jurassic faunas of the Circum-Pacific Region were at best chaotic and ended in bizarre zoogeographic reconstructions. Hölder (1979, p. A391), for example, in discussing Jurassic marine zoogeography, described the Circum-Pacific Jurassic as lacking faunistic uniformity; in fact, he (p. A401) went as far as entitling a section of his chapter: "Faunal Mosaic of the Pacific Ocean".

Recognition of displaced terranes depends primarily on paleolatitudinal data derived either from paleomagnetism or paleontology. Taylor *et al.* (1984, p. 122) noted that "Faunal analysis can thus, in favourable cases, provide the following indications that are often beyond the reach of paleomagnetic studies. It can (a) decide whether a terrane at a given time was in the northern or southern hemisphere, thereby placing constraints on the polarity of paleomagnetic determinations; (b) indicate displacements of as little as a few hundred kilometers; and (c) provide longitudinal constraints." The longitudinal constraints offered by faunal analysis are definitely beyond the reach of paleomagnetism and should be heeded by all geologists attempting to determine the origin of a displaced terrane. For example, the Tethyan bivalve *Weyla* Boehm, 1922, occurs in Lower Jurassic strata from Chile to Alaska (Damborenea and Mancenido, 1979; Pessagno and Blome, 1986); it does not occur in the western Pacific. *Weyla* occurs in the Lower Jurassic of the Sierran terranes, the Mesozoic clastic terrane (Blue Moun-



Text-figure 1.—Map showing distribution of geologic terranes in the Blue Mountains Province of east-central and northeastern Oregon, southeastern Washington, and northwestern Idaho (modified from Dickinson, 1979).

tains Province), and Wrangellia (Imlay, 1968, 1980; Pessagno and Blome, 1986; Taylor *et al.*, 1984). This, as well as other faunal evidence, indicates that these terranes originated in the eastern Pacific.

Pessagno, Blome, and Longoria (1984, pp. 19–20) and Pessagno and Blome (1986) developed simple criteria for differentiating the radiolarian assemblage of the Tethyan Realm from that of the Boreal Realm (Text-figs. 2, 3). Furthermore, they subdivided each of these faunal realms into provinces. The Tethyan Realm was subdivided into (1) a Central Tethyan Province characterized by the presence of *Ristola* Pessagno and Whalen, 1982, and high pantanelliid abundance and diversity and (2) a Northern Tethyan Province characterized by the presence of common *Parvicingula* Pessagno, 1977a (*sensu* Pessagno and Whalen, 1982) and high pantanelliid abundance and diversity. They subdivided the Boreal Realm into (1) a Southern Boreal Province delimited by abundant and diversified *Parvicingula* and a dramatic drop in pantanelliid abundance and diversity and (2) a Northern Boreal Province distinguished by abundant *Parvicingula* and by a total lack of pantanelliids. In general, pantanelliid diversity is three or four times greater in the Tethyan Realm than it is in the Southern Boreal Province. This estimate is based on analyses of well-preserved material extracted from limestone samples from east-central Mexico (Northern Tethyan), Greece (Central Tethyan), the California Coast Ranges (Southern Boreal), and the Klamath Mountains (California; Southern Boreal). Many, but not all, radiolarian chert samples are too diagenetically altered to allow the recovery of well-preserved pantanelliids and other fragile Radiolaria; usually only Radiolaria with very sturdy tests (*e.g.*, *Mirifusus* Pessagno, 1977a) are preserved.

Because of the displaced terrane problem, Pessagno and Blome (1986) treated all megafossil data from the western part of the Cordilleran Region as suspect unless faunal associations or paleomagnetic data were cited. Moreover, in their discussions of the Triassic and Jurassic faunas of the Blue Mountains Province (eastern Oregon and western Idaho), they evaluated the megafossil data in light of the distribution of taxa in areas that have not been greatly displaced latitudinally (*e.g.*, the western interior of North America; western Europe). In addition, they utilized the paleo-oceanographic reconstructions of Gordon (1974) and the paleolatitudinal maps of Smith, Hurley, and Briden (1981) in their interpretations. One must, however, keep in mind that cratonic North America was situated at lower latitudes during the Triassic and Early Jurassic than it was during Middle and Late Jurassic times. With the movement of the craton in a northerly direction during the Triassic and Jurassic, paleolatitudinal lines, faunal realm, and faunal province boundaries shifted progressively to the south (see Smith, Hurley, and Briden, 1981).

The boundary between the Tethyan and Boreal Realms was situated at approximately 30°N during the Jurassic (Pessagno, Longoria, MacLeod, and Six, [in

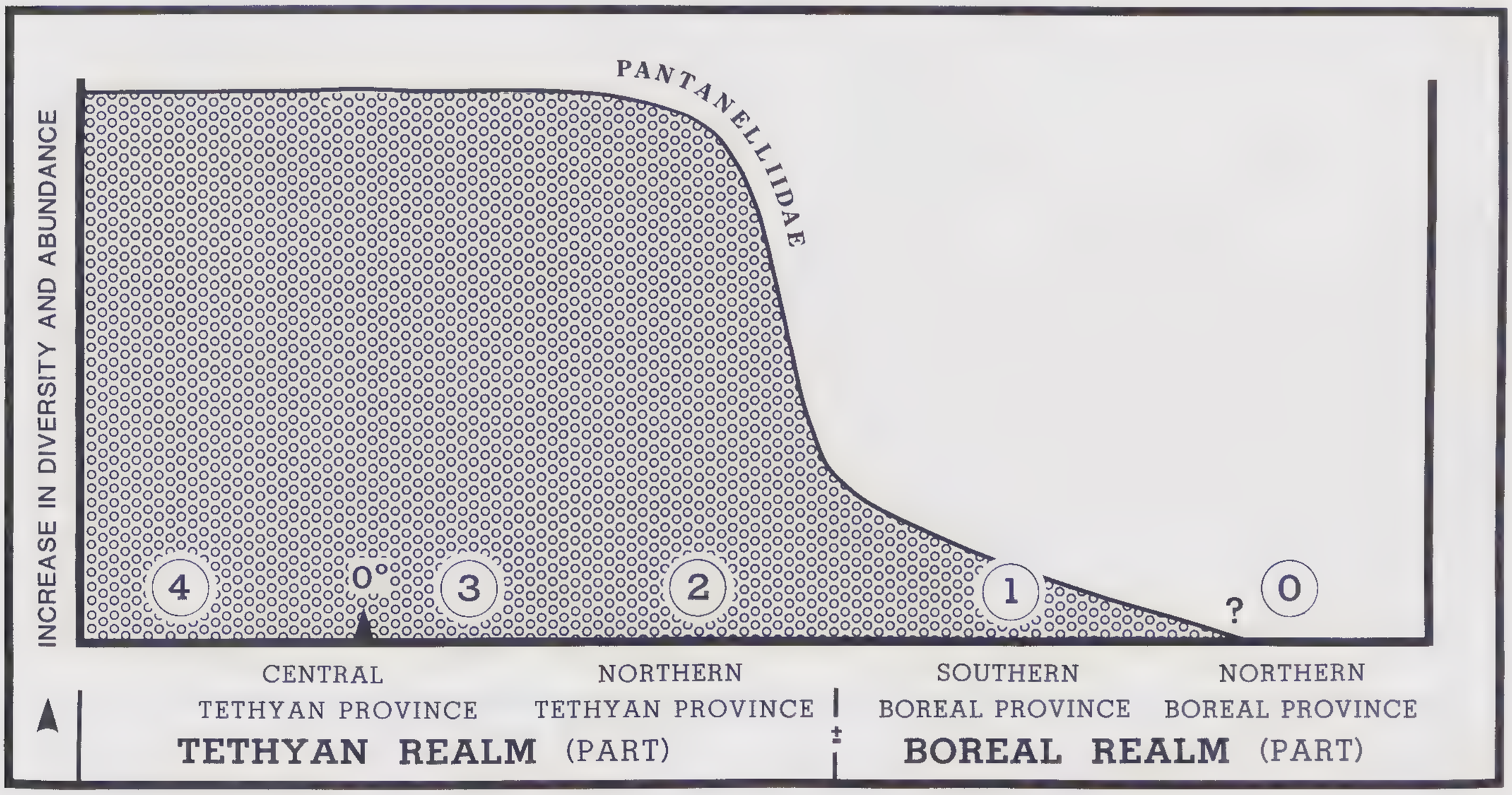
Text-figure 2.—Models showing the relationship of radiolarian diversity and abundance to their paleolatitudinal distributions in the Middle and Late Jurassic of western North America.

A—Model depicting pantanelliid diversity during the Middle and Late Jurassic. Well-preserved Tethyan pantanelliid assemblages possess three or four times more species-level taxa (described and undescribed forms) that those in the Southern Boreal Province (Boreal Realm). Our data indicate that pantanelliids are absent in the Northern Boreal Province.

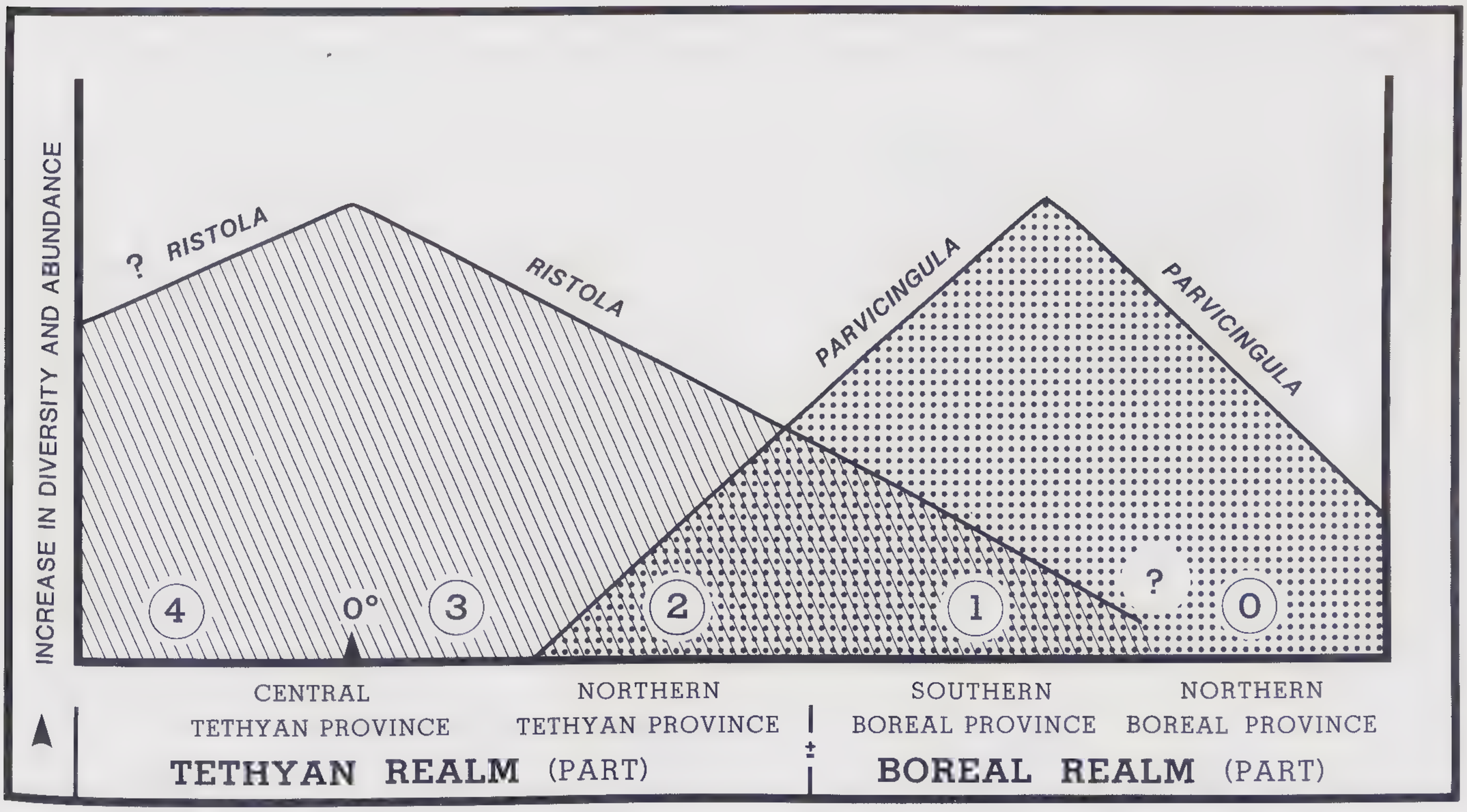
B—Model showing distribution of *Parvicingula* Pessagno, 1977a (*sensu* Pessagno and Whalen, 1982) and *Ristola* Pessagno and Whalen, 1982, during Middle and Late Jurassic times. Central Tethyan Province faunas lack *Parvicingula* and are characterized by the presence of *Ristola*. Northern Tethyan and Boreal Province faunas contain both *Parvicingula* and *Ristola*. *Parvicingula* is the dominant element among the Parvicingulidae Pessagno, 1977a (*sensu* Pessagno and Whalen, 1982) in the Boreal Realm.

0 = Data from North Slope/Brooks Range and Puale Bay areas of Alaska. At Puale Bay, Blome (1984b) has recovered well-preserved middle Callovian Radiolaria occurring at the same horizon as *Stenocadoceras* Imlay, 1953. *Stenocadoceras* is a high-latitude Boreal ammonite taxon that occurs elsewhere in Russia and Greenland; **1** = Data from the upper half of volcanogenic–pelagic successions overlying the Coast Range ophiolite, from the Great Valley Supergroup (California Coast Ranges), from the Galice Formation *s. l.* (Klamath Mountains, California), and from the Upper Jurassic (upper Tithonian) part of the Eugenia Formation, Vizcaino Peninsula, Baja California Sur, Mexico. Common to abundant *Buchia* Rouillier, 1845, are associated with the radiolarian faunas in the Great Valley Supergroup, the Galice Formation, and the Eugenia Formation; **2** = Data from the Taman and Pimienta formations of east-central Mexico. Radiolarian faunas here are associated with Tethyan ammonites, pectenacids (e.g., *Aulacomyella* Furlani, 1910), calpionellids, and nannoconids. Upper Jurassic Mexican radiolarian faunas from this area are characterized by high pantanelliid diversity and the presence of common *Parvicingula* Pessagno, 1977a. Other data from Lower Jurassic (Toarcian) and Middle Jurassic (Aalenian to upper Bajocian) portion of Snowshoe Formation (Blue Mountains Province, east-central Oregon; p. 14 herein); **3** = Data from the Mediterranean area, Turkey, Iran, Oman, Tibet, and various Deep-Sea Drilling Project sites in the North Atlantic (*e.g.*, Site 367, Cape Verde Basin; Site 534, Blake–Bahama Basin; Baumgartner, 1984). Central Tethyan Province radiolarian faunas lack *Parvicingula* Pessagno, 1977a (*sensu* Pessagno and Whalen, 1982) and also, when well-preserved, display high pantanelliid diversity. No Central Tethyan Province faunas are known from North America except from displaced terranes and subduction complexes (*e.g.*, Coast Range ophiolite and overlying volcanogenic–pelagic strata, Franciscan Complex, California; Pacific Rim complex, Vancouver Island, British Columbia); **4** = No data from the southern hemisphere. Model assumes symmetrical arrangement of faunal provinces and realms north and south of Middle to Upper Jurassic paleoequator. Boundary between Central and Northern Tethyan Provinces is placed at approximately 22 degrees North. Boundary between Tethyan and Boreal Realms is placed at approximately 30 degrees North. Obviously, fluctuations of all of these boundaries are likely to occur relative to a given paleolatitudinal position due to differences in oceanic circulation.

press]). In the Late Jurassic (late Tithonian), for example, the occurrence of Tethyan microfossils (*i.e.*, calpionellids) at this paleolatitude off the Scotia Shelf and Grand Banks and their distribution in western Europe tend to support this conclusion (Edgell, 1971; Jansa, Remane, and Ascoli, 1980; Smith, Hurley, and Briden, 1981). The boundary between the Northern Tethyan Province and the Central Tethyan Province



A



B

is placed at approximately 22°N in eastern Mexico. Mexican strata containing Northern Tethyan radiolarian faunas also contain calpionellids as well as Tethyan ammonites and bivalves (Pessagno, Longoria, MacLeod, and Six [in press]). This estimate takes into account the southeasterly displacement of Northern Tethyan strata (*e.g.*, Taman Formation) in Puebla, Hildalgo, Veracruz, and San Luis Potosí along megashear systems (see Longoria, 1984, 1985). Jurassic (mostly Late Jurassic) Central Tethyan radiolarian faunas occur in Oman, Iran, Turkey, and throughout the Mediterranean area (see, *e.g.*, Tippit, 1981; Baumgartner, 1984). Late Jurassic Central Tethyan faunas also occur in the Cape Verde Basin and the Blake–Bahama Basin in the North Atlantic (Baumgartner, De Wever, and Kocher, 1980; Baumgartner, 1984). As already noted, Middle and Late Jurassic Central Tethyan faunas occur in red ribbon cherts commonly associated with subduction complexes around much of the Circum-Pacific margin (Baja California to Alaska, Japan, East Indies). Central Tethyan faunas likewise occur in Late Jurassic tuffaceous cherts overlying the Coast Range ophiolite (California; Pessagno, Blome, and Longoria, 1984). No definitely autochthonous Central Tethyan faunas are known from North America. Northern Tethyan radiolarian faunas are known from Late Jurassic strata in the California Coast Ranges, western Oregon, east-central Mexico, and northeastern Mexico (Pessagno, Blome, and Longoria, 1984; Pessagno, Longoria, MacLeod, and Six [in press]). They are also well represented in the Early Jurassic (Toarcian) and Middle Jurassic (Aalenian, Bajocian) of east-central Oregon (Pessagno and Blome, 1980; Pessagno and Whalen, 1982; Pessagno and Blome, 1986). To date, Northern Tethyan faunas have not been reported from western Europe.

Southern Boreal radiolarian faunas are presently only known from North American terranes. They occur in the Late Jurassic strata of the California Coast Ranges (Pessagno, 1977a; Pessagno, Blome, and Longoria, 1984), Klamath Mountains of California (Pessagno, unpublished data), and the Vizcaino Peninsula of Baja California Sur, Mexico (Davila, 1986). They are also well represented in the Middle Jurassic (Bathonian, Callovian) of east-central Oregon (terranes of the Blue Mountains Province; Pessagno and Blome, 1986). In the Late Jurassic, the Southern Boreal assemblage is usually associated with abundant *Buchia* Rouillier, 1845. The Northern Boreal assemblage is known from the Jurassic of the Alaskan Peninsula (Puale Bay; Blome, 1984b), southwestern Alaska (Pessagno, unpublished data), and the North Slope of Alaska (Pessagno, unpublished data). At Puale Bay Blome's very well-preserved Northern Boreal assemblage is associated with *Stenocadoceras* (Imlay, 1953). *Stenocadoceras* is a high latitude Boreal ammonite taxon, which is known elsewhere from Russia and Greenland (Arkell, Kummel, and Wright, 1957, p. L302; Taylor *et al.*, 1984, p. 133, fig. 16).

"Tethyan Realm" and "Boreal Realm" as used in this report correspond for the most part to the usage of Taylor *et al.* (1984). However, some differences are evident particularly in the Late Jurassic (late Oxfordian to late Tithonian). For example, the late Tithonian portion of the Great Valley Supergroup (California Coast Ranges) would be regarded by these authors as Tethyan because it contains ammonites such as *Kossmatia* Uhlig, 1907, *Parodontoceras* Spath, 1923, and *Proniceras* Burckhardt, 1919. We regard these strata as Southern Boreal because they lack calpionellids and contain abundant *Buchia* Rouillier, 1845, in association with abundant *Parvicingula* Pessagno, 1977a (*sensu* Pessagno and Whalen, 1982) and poorly-diversified pantanelliids. In contrast, we agree closely with Taylor *et al.* (1984) in the differentiation of Tethyan and Boreal strata in the John Day Inlier (Blue Mountains Province, east-central Oregon; see below). Other realms and provinces noted by these authors cannot be distinguished at present through our analysis of the Jurassic radiolarian assemblage.

Terranes from which our radiolarian faunas are derived in this report are discussed below. All of these terranes have been displaced to some degree paleolatitudinally.

Wrangellia Terrane, Queen Charlotte Islands, British Columbia

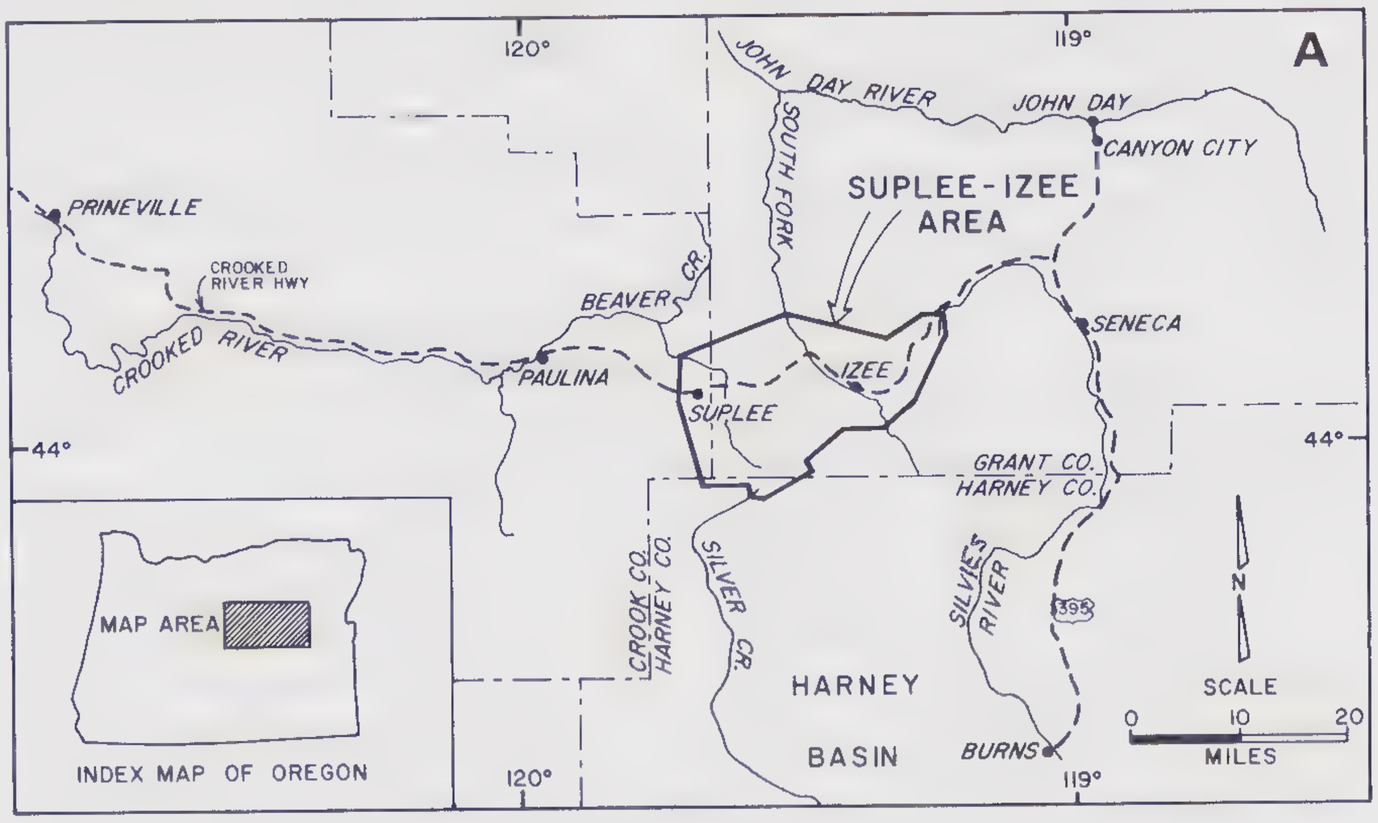
The Queen Charlotte Islands (Text-fig. 4) are part of the Wrangellia terrane of Jones, Silberling, and Hillhouse (1977). Paleomagnetic data presented by Jones, Silberling, and Hillhouse (1977) indicate that Wrangellia originated 15° north or south of the Triassic paleoequator. During the Late Triassic and Early Jurassic both the molluscan and radiolarian assemblages tend to be predominantly Tethyan (Tipper, 1981; Taylor *et al.*, 1984; Pessagno and Blome, 1986). However, the presence of very rare Boreal ammonites (amaltheids) in the upper Pliensbachian portion of the Maude Formation suggests that the Queen Charlotte Islands component of Wrangellia was situated in the northern hemisphere (Taylor *et al.*, 1984, pp. 128, 135). The radiolarian assemblage during the Late Triassic (Norian) and Early Jurassic (Hettangian to Toarcian) is characterized by an abundant, diversified pantanelliid

Text-figure 3.—Indicators of faunal realms and provinces. Distribution of selected radiolarian and megafossil taxa, and various other microfossils (*e.g.*, calpionellids) in faunal realms and provinces during the Middle and Late Jurassic.

	TETHYAN FAUNAL REALM			BOREAL FAUNAL REALM	
	SOUTHERN TETHYAN PROVINCE	CENTRAL TETHYAN PROVINCE	NORTHERN TETHYAN PROVINCE	SOUTHERN BOREAL PROVINCE	NORTHERN BOREAL PROVINCE
		0°			
MIDDLE AND LATE JURASSIC RADIOLARIANS	? ***Mirifusus*** Pessagno, 1977a ?				
			Parvicingula Pessagno, 1977a ?		
	? ***Ristola*** Pessagno & Whalen, 1982 ?				
	? ***Hsuum*** Pessagno, 1977a				
		? ***Perispyridium*** Dumitrica, 1978 ?			
		Turanta Pessagno & Blome, 1982			
	? ***Napora*** Pessagno, 1977a ?				
		? ***Hilarisirex*** Takemura & Nakaseko, 1982			
	? ***Pantanellium*** Pessagno ,1977a				
	? ***Trillus*** Pessagno & Blome, 1980				
		? ***Zartus*** Pessagno & Blome, 1980			
	? ***Emiluvia*** Foreman, 1973				
	? ***Tripocyclia*** Haeckel, 1881				
	? ***Acanthocircus dicranocanthus*** Squinabol, 1914				
	? ***Podocapsa amphitreptera*** Foreman, 1973				
	? ***"Eucyrtidium" ptyctum*** Riedel & Sanfilippo, 1974				
BIVALVES				***Buchia*** Rouillier, 1845	
	? ***Aulacomyella*** Furlani, 1910				
AMMONITES — Late Jurassic	? ***Kossmatia*** Uhlig, 1907				
	Glochiceras Hyatt, 1900				
	? ***Idoceras*** Burckhardt, 1906				
				Amoebites Buckman, 1925	
				Cardioceras Neumayr & Uhlig, 1881	
				Scarburgiceras Buckman, 1924	
AMMONITES — Middle Jurassic	***Reineckeia*** Bayle, 1878				
				Stenocadoceras Imlay, 1953	
				Kepplerites Neumayr & Uhlig, 1892	
	Grossouvria Siemiradzki, 1898			***Cranocephalites*** Spath, 1932	
				Lilloetia Crickmay, 1930	
	Stephanoceras Waagen, 1869				
	Sonninia Bayle, 1879				
					Arkelloceras Frebold, 1957
		? ***Normannites*** Munier-Chalmas, 1892			
		? ***Tmetoceras*** Buckman, 1892			?
OTHER PROTISTANS LATE JURASSIC	**Calpionellids**				

assemblage (see Pessagno and Blome, 1980; Blome, 1984a). However, the fact that Carter (written commun., 1985) recorded *Parvicingula* Pessagno, 1977a (*sensu* Pessagno and Whalen, 1982) in the middle Toarcian portion of the Maude Formation suggests that this portion of Wrangellia was at Northern Tethyan paleolatitudes by the middle Toarcian.

In the following stratigraphic summary, we discuss only those formational units that bear Radiolaria described in *Systematic Paleontology*.



Text-figure 4.—Maps showing some of the localities described in this report.

A—Location of the Suplee-Izee area of Dickinson and Vigrass (1965) and adjoining areas in east-central Oregon; B—Index map of the Queen Charlotte Islands, British Columbia (from Pessagno and Blome, 1980).

Stratigraphic Summary

Kunga Formation

The Kunga Formation (Sutherland Brown and Jeffrey, 1960; Sutherland Brown, 1968) consists of siliceous mudstone ("argillite"), limestone, and sandstone. It rests comformably(?) on the Karmutsen Formation (Ladinian to Karnian) and either conformably beneath the Maude Formation (late Sinemurian?; early Pliensbachian to Toarcian) or unconformably beneath the Yakoun Formation (Middle Jurassic).

Sutherland Brown (1968, p. 51) divided the Kunga Formation into three informal members: (1) a lower massive gray limestone member that conformably(?) overlies the tholeiitic basalts (greenstones) of the Karmutsen Formation; (2) a middle, thin-bedded black limestone member; and (3) an upper thin-bedded black argillite member. The lower member is characterized by massive, gray-weathering recrystallized limestone with poorly-preserved corals, pelecypods, and ammonites. The only biostratigraphically significant fossils are rare *Halobia* sp. and *Arcestes*(?) sp. According to Sutherland Brown (1968, p. 61) the lower limestone member is "—Karnian, older than the *Tropites welleri* Zone." At the type locality of the Kunga Formation at Kunga Island this unit is 183 m (600 ft) thick. The middle black limestone member includes predominantly thin-bedded, flaggy, black, carbonaceous, micritic black limestone with lesser amounts of cross-bedded calcarenite, fine limestone conglomerate, black siliceous mudstone ("argillite"), and rare lithic sandstone. At Kunga Island the middle member is 267 m (905 ft) thick. The middle member contains common but poorly-preserved pectenacids and rare ammonites. *Monotis subcircularis* Gabb, 1864, was recorded by both Sutherland Brown (1968) and Blome (1984a) in the upper part of this unit. The molluscan assemblage indicates that this member ranges in age from late early Karnian at its base to latest Norian at its top. Blome (1983, 1984a) recovered abundant well-preserved Radiolaria from the uppermost (upper Norian) part of the middle member and assigned this assemblage to the *Betraccium* Zone, *B. deweveri* Subzone. The upper black argillite member is characterized by thin, often rhythmically bedded black siliceous mudstone ("argillite"), which superficially resembles ribbon chert. Minor lithic types include black, thin-bedded, micritic limestone, gray bioclastic limestone, dark-gray to greenish-gray lithic sandstone, and thin-bedded, black, calcareous shale. At Kunga Island the upper member is 497 m (1630 ft) thick. Sinemurian arietitid ammonites (e.g., *Arietites* Waagen, 1869) occur in all but the lower 56 m (184 ft) of the upper member. The lower interval between the last occurrence of *Monotis subcircularis* Gabb, 1864, at the top of the middle member and the first occurrence of Sinemurian ammonites contains a rich, well-preserved radiolarian assemblage that is considerably different from that of the overlying Sinemurian and radically different from that of the underlying upper Norian. It contains some elements, such as *Canoptum merum* Pessagno and Whalen, 1982, and *Pantanellium kluense* Pessagno and Blome, 1980, that also occur in the Graylock Formation (Hettangian) of east-central Oregon. Neither of these taxa has been observed either in the underlying latest Norian strata with *Monotis subcircularis* or in overlying Sinemurian strata with *Arietites*.

Maude Formation

The Maude Formation (MacKenzie, 1966; Sutherland Brown, 1968) includes dark-gray to black shale, siliceous mudstone ("argillite"), limestone, siltstone, and lithic sandstone. Bedded limestone and limestone nodules (black micrites) with abundant Radiolaria are common to abundant throughout most of the unit. The Maude Formation conformably overlies the Kunga Formation and disconformably(?) underlies the Yakoun Formation (Middle Jurassic). Sutherland Brown (1968, p. 61) indicated that the Maude Formation reaches a maximum thickness of 183 to 213 m (600 to 700 ft). He stated, basing his conclusions on those of Frebold (1970), that the Maude Formation at its type locality at Maude Island ranges in age from late Sinemurian to Toarcian. The late Sinemurian age is questionable at least at the type locality in that Frebold (*in* Sutherland Brown, 1968, p. 65) indicated that both late Sinemurian and early Pliensbachian ammonites occur in the same one-foot bed in the lower part of the Maude. Detailed stratigraphic studies in progress by Dr. Howard Tipper and Mr. Bruce Cameron (Geological Survey of Canada) should resolve this problem.

Blue Mountains Province of Northeast and East-central Oregon

The Blue Mountains Province contains four major tectonostratigraphic terranes that crop out discontinuously in northeast-southwest trending belts beneath a Cenozoic volcanic cover (Dickinson, 1979). From northeast to southwest these terranes are the Seven Devils terrane, the Central melange terrane, the Mesozoic clastic terrane, and the Huntington arc terrane (Dickinson, 1979; see Text-fig. 1). Many of the radiolarian-bearing samples utilized in the present study are derived from part (Suplee–Izee area) of the Mesozoic clastic terrane.

A detailed discussion of the aforementioned terranes was presented by Pessagno and Blome (1986). Some of their conclusions are as follows:

(1) The Seven Devils terrane, Central melange terrane, and Huntington arc terrane all represent dismembered components of a single island-arc complex.

(2) Faunal data from the Seven Devils, Mesozoic clastic, and Huntington arc terranes demonstrate that these terranes all resided in the Central Tethyan Province during the Late Paleozoic, Triassic, and most of the Early Jurassic; in the Northern Tethyan Province from the middle Toarcian (Early Jurassic) to the latest Bajocian (Middle Jurassic); in the Southern Boreal Province during the Bathonian and Callovian (Middle Jurassic); and at possible higher Boreal latitudes during the early Oxfordian (Late Jurassic). The shift from the Central Tethyan to Northern Tethyan Province is reflected by the appearance of *Parvicingula* Pessagno, 1977a (*sensu* Pessagno and Whalen, 1982) in the middle and late Toarcian strata of the Snowshoe Formation (Warm Springs Member, Mesozoic clastic terrane, Suplee–Izee area). The shift from the Northern Tethyan Province to the Southern Boreal Province is marked by a dramatic drop in pantanelliid diversity and abundance between the late Bajocian and late Bathonian (Mesozoic clastic terrane). There is a continual drop in pantanelliid diversity from the early Bajocian (= middle Bajocian of Imlay, 1973, and Pessagno and Blome, 1980) onwards. More than twenty species-level taxa (named and unnamed forms) are present in the Aalenian and lower Bajocian; seven are present in the upper Bajocian (upper part of *Megasphaeroceras rotundum* Zone of Hall and Westermann, 1980); two are present in the upper Bathonian (= lower Callovian of Imlay, 1964a, and Pessagno and Blome, 1980); and one is present in the Callovian. A drop in diversity is also reflected in the ammonite assemblage between the late Bajocian and late Bathonian and Callovian (see Imlay, 1973, 1981). In addition, the ammonite assemblage contains a predominance of Boreal Bathonian and Callovian genera such as *Torricelliceras* Buckman, 1922, *Kepplerites* Neumayr and Uhlig, 1892, and *Pseudocadoceras* Buckman, 1918. Missing are Callovian Tethyan taxa such as *Reineckeia* Bayle, 1878, which, exclusive of the Circum-Pacific area of suspect and displaced terranes, occurs in east-central Mexico (Cantu Chapa, 1971; Imlay, 1980; Taylor *et al.*, 1984), North Africa, and in the alpine-Himalayan belt (Arkell, Kummel, and Wright, 1957).

(3) A Central Tethyan origin for the terranes of the Blue Mountains Province is not inconsistent with existing paleomagnetic data. Hillhouse, Gromme, and Vallier (1982) indicated that the Seven Devils and Huntington arc terranes were situated 18° (±4°) north or south of the Triassic paleoequator.

(4) The presence of *Weyla* Boehm, 1922, and *Plicatostylus* Lupher and Packard, 1930, in Lower Jurassic strata, and ammonites such as *Lupherites* Imlay, 1973, in Middle Jurassic strata (Mesozoic clastic terrane) suggests that the Blue Mountains island arc complex originated in the eastern Pacific (Pessagno and Blome, 1986; Smith, 1980; Westermann, 1981; Taylor *et al.*, 1984).

(5) Movement of the Blue Mountains island arc complex to Boreal latitudes is coincident with the opening of the Gulf of Mexico during the late Bathonian or Callovian (Pessagno and Blome, 1986). It is likely that the Blue Mountains island arc complex was carried to higher latitudes along megashear systems that are genetically related to those in Mexico (see Longoria, 1984, 1985).

Stratigraphic Summary, Suplee–Izee Area (Mesozoic clastic terrane)

The stratigraphic summary provided below only includes radiolarian-bearing lithostratigraphic units mentioned in *Systematic Paleontology*. No attempt is made to describe the entire succession of the Suplee–Izee area and adjoining areas within the Mesozoic clastic terrane.

Nicely Formation

The Nicely Formation (Lupher, 1941; Dickinson and Vigrass, 1965; Imlay, 1968) consists of 23 m to 91 m (75–300 ft) of dark-gray, silty shales and mudstones often typified by an abundance of variable-sized dark-gray to black, micritic limestone nodules. The limestone nodules frequently contain megafossils and abundant Radiolaria.

The Nicely Formation rests conformably upon the Suplee Formation (upper Sinemurian?, lower Pliensbachian?; upper Pliensbachian) and beneath the Hyde Formation (upper Pliensbachian to middle Toarcian). Investigations of the Nicely ammonite fauna by Imlay (1968, pp. C8–C9) indicate that it is correlative with both the European *Amaltheus margaritatus* and *Pleuroceras spinatum* Standard Zones of the upper Pliensbachian.

Hyde Formation

The Hyde Formation (Lupher, 1941; Dickinson and Vigrass, 1965) includes 305 m (1000 to 1200 ft) of massive, blue-gray andesitic tuff and tuffaceous volcanic wacke (turbidite). Thinner beds of tuffaceous mudstone with dark-gray limestone nodules occur at some horizons. The Hyde Formation rests conform-

ably beneath the Warm Springs Member of the Snowshoe Formation (see below).

Megafossils are rare and fragmentary in the Hyde Formation. However, Radiolaria are abundant at some horizons and commonly are well-preserved in the finer-grained clastics and limestone nodules. The age of the Hyde can only be established by superposition. It rests above Nicely strata bearing late Pliensbachian ammonites and below Snowshoe strata bearing late Toarcian ammonites. Most of the unit is probably early Toarcian; however, it may well include late Pliensbachian strata at its base and middle Toarcian strata at its top. Future studies of the radiolarian assemblage offer the best opportunity to determine the age of this unit.

Snowshoe Formation

The Snowshoe Formation (Lupher, 1941; Dickinson and Vigrass, 1965) in its type area at Izee (Text-fig. 1) includes 838 m (2750 ft) of dark-gray to black mudstone, shale, volcaniclastic siltstone, tuff breccia, and volcaniclastic sandstone. Micritic, dark-gray to black limestone nodules containing abundant, well-preserved Radiolaria occur in the finer-grained clastics. In its type area Dickinson and Vigrass (1965) subdivided the Snowshoe Formation into a lower member, a middle member, and an upper member. More recently, Smith (1980, pp. 1603–1608) applied the names "Warm Springs Member", "Schoolhouse Member", and "South Fork Member" to these same units (see below). To the east and west of the type area at Izee, the Schoolhouse Member interfingers respectively with the tuff, volcaniclastic sandstone, and tuff breccia of the Silvies Member and the Basey Member (see Dickinson and Vigrass, 1965). The Snowshoe Formation rests conformably on the Hyde Formation and either conformably or unconformably beneath the Trowbridge Formation (upper Bathonian to lower Callovian). The combined radiolarian and ammonite biostratigraphic data indicate that the Snowshoe Formation in its type area near Izee ranges in age from middle Toarcian at its base to late Bathonian at its top (Imlay, 1981; see loc. OR-589 in *Appendix*).

Warm Springs Member.—The Warm Springs Member (Lupher, 1941; Dickinson and Vigrass, 1965; Smith, 1980) consists of 140 to 200 m (459 to 656 ft) of reddish-brown weathering, black to dark-gray mudstone, fissile shale, and siltstone. Lenticular masses of micritic to silty limestone and common micritic, dark-gray limestone nodules are common at most localities. Ammonites frequently occur in the limestone nodules and finer-grained clastics. Abundant Radiolaria occur in the limestone nodules. The contact of the Warm Springs Member with the volcanic wacke of the underlying Hyde Formation is conformable and may be either sharp or gradational in the area near Izee (Text-fig. 4).

Radiolarian and ammonite data indicate that the Warm Springs Member ranges in age from middle Toarcian to early Bajocian (Imlay, 1973; see loc. OR-589 in *Appendix* for Toarcian data). At Schoolhouse Gulch immediately north of Izee (Text-fig. 4), the lower 26.8 m (88 ft) of the Warm Springs Member are assignable to the middle and upper Toarcian (= *thouarsense, variabilis,* and *levesquei* Standard Zones). The remainder of the Warm Springs Member near Izee is assignable to the Aalenian (= lower Bajocian of Imlay, 1973; Pessagno and Blome, 1980; Pessagno and Whalen, 1982) and lower Bajocian (= middle Bajocian of Imlay, 1973). Aalenian strata contain *Tmetoceras* Buckman, 1892, and *Eudmetoceras* Buckman, 1920, and are placed by Imlay (1980, p. 23) in the middle and upper Aalenian. Evidence for the lower Aalenian *opalinum* Standard Zone is lacking (Hall and Westermann, 1980). Lower Bajocian Warm Springs strata contain ammonites that are correlative with the standard European *discites, laeviuscula, sauzei,* and *humphriesianum* Standard Zones (Smith, 1980, p. 1606). Smith indicates that the upper part of the Warm Springs Member decreases in age from southwest to northeast.

Schoolhouse Member.—The Schoolhouse Member in its type area near Izee consists of 300 m (984 ft) of laminated, gray, green, and rarely buff-colored siltstone and sandstone that alternate with mudstone and shale similar to those of the Warm Springs Member. Laminae range in thickness from 1 mm to 1 cm (Smith, 1980, p. 1605). Dickinson and Vigrass (1965) indicate that the coarser layers are graded and consist mostly of andesitic plagioclase and rock fragments, which were originally glassy but now are zeolitized. The Schoolhouse Member conformably overlies the Warm Springs Member and rests conformably beneath the South Fork Member.

The Schoolhouse Member contains a lower to upper Bajocian ammonite assemblage (Imlay, 1973; Smith, 1980), which is correlated with the European *laeviuscula, sauzei, humphriesianum,* and *subfurcatum* Standard Zones. Smith (1980, p. 1607) indicated that the lower part of the Schoolhouse Member to the northeast at Bunton Hollow is younger than the upper part of the unit to the southwest at Flat Creek and Pole Canyon.

South Fork Member.—The South Fork Member (Dickinson and Vigrass, 1965, p. 47; Smith, 1980, p. 1605) consists of over 500 m (1640 ft) of dark-gray to

black shale and mudstone, with gray calcareous, partly volcaniclastic sandstone, which rests conformably on the Schoolhouse Member and either conformably (*e.g.*, near Izee) or unconformably (Loc. OR-513 [see *Appendix*]) beneath the Trowbridge Formation (upper Bathonian(?); lower Callovian). The graded nature of the sandstone strata suggests that they are turbidites (Smith, 1980, p. 1605). The South Fork Member thins from northeast to southwest. At Pole Canyon and at Flat Creek to the southwest of Izee and south of the South Fork of the John Day River, the South Fork Member is missing due to erosion (Text-fig. 4). In this case, the Trowbridge Formation rests unconformably on the Schoolhouse Member. The lower part of the South Fork Member in the Izee area contains upper Bajocian ammonites that are correlative with the European *subfurcatum* Standard Zone and the American *Megasphaeroceras rotundum* Zone (Smith, 1980, pp. 1606–1607). Upper Bathonian ammonites have been reported by Imlay (1981, p. 10) from the upper 183 to 213 m (600 to 700 ft) of the South Fork Member along Rosebud Gulch north of Izee.

Lonesome Formation

The Lonesome Formation (Lupher, 1941; Dickinson and Vigrass, 1965) includes approximately 3050 m (10,000 ft) of monotonous, flysch-like interbedded gray, graded sandstone and dark-gray mudstone typically exposed on the South Fork of the John Day River southeast of Izee (Text-fig. 4). This unit rests conformably on the dark-gray, black, and often green tuffaceous shale and sandstone of the Trowbridge Formation (latest Bathonian to early Callovian) and unconformably beneath Tertiary volcanic rocks (Dickinson and Vigrass, 1965). Imlay's (1981) recent revision of the ammonite biostratigraphy indicates that the Lonesome Formation is of early and early middle Callovian age. To date, only sparse (silicified and calcified) Radiolaria have been recovered from this unit (Pessagno and Blome, 1980; Pessagno and Whalen, 1982; Pessagno and Blome, 1982; Blome 1984b).

The Coast Range Ophiolite and Associated Strata

California Coast Ranges

The genesis of the Coast Range ophiolite and its associated sedimentary strata has been discussed in detail by Hopson, Mattinson, and Pessagno (1981). A revision of the chronostratigraphy and radiolarian biostratigraphy was presented by Pessagno, Blome, and Longoria (1984).

From earlier and current analyses of these rocks, the following facts are evident:

(1) Strata associated with pillow basalts within the Coast Range ophiolite are invariably red, manganiferous radiolarian cherts and minor pelagic limestones lacking tuffaceous (calc-alkaline) contributions. The red ribbon cherts are identical to those that characterize the Franciscan Complex. Their presence within the ophiolite at numerous localities indicates that the spreading center for the Coast Range ophiolite was not in the immediate vicinity of an island arc at the time when oceanic crust was being generated.

(2) Strata overlying the Coast Range ophiolite at all localities are always green to black tuffaceous chert, tuff, tuff breccia, and occasional lenses and beds of light-gray pelagic limestone.

(3) U/Pb dates of the Coast Range ophiolite range in age from 153 ± 3 m.y. at Cuesta Ridge (San Luis Obispo Co.), 161 ± 3 m.y. at Point Sal (Santa Barbara Co.), 156 ± 3 m.y. at Arroyo del Puerto (Stanislaus Co.), and 164 ± 3 m.y. at Llanada (San Benito Co.) (see Hopson, Mattinson, and Pessagno, 1981). According to Hopson, Mattinson, and Pessagno (1981, p. 466), Deborah Fritz (Univ. of Texas at Austin) reported a 163 ± 5 m.y. K/Ar age on the Paskenta remnant (Tehama Co.) of the Coast Range ophiolite.

(4) In Northern Tethyan strata in eastern Mexico (Taman Formation) and in Southern Boreal strata in the California Coast Ranges, Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984) can be divided into an upper portion whose base is marked by the first occurrence of *Parvicingula* Pessagno, 1977a, *s. s.* and a lower portion characterized by the presence of *Parvicingula s. l.* *Parvicingula s. s.* includes forms (e.g., *P. santabarbaraensis* Pessagno, 1977a) that possess a long, slender, yet sturdy tube on the final post-abdominal chamber; *Parvicingula s. l.* includes forms (e.g., *P. profunda* Pessagno and Whalen, 1982; *P. vera* Pessagno and Whalen, 1982) that lack the post-abdominal apparatus. If *Parvicingula s. l.* possesses a post-abdominal tube, it is most likely quite broad and fragile, and similar to that of *Canoptum* Pessagno, 1979.

In east-central Mexico (San Luis Potosí) *Parvicingula s. s.* first appears well above the base of the *Glochiceras* gp. *fialar* Zone (upper Kimmeridgian *sensu gallico**; Cantu Chapa, 1971) in the upper part of the lower member of the Taman Formation. However, it cannot be determined at present whether *Parvicingula s. s.* first appears in the uppermost part of the *G.* gp. *fialar* Zone (uppermost Kimmeridgian) or in the lowermost part of the overlying *Virgatosphinctes mexicanus–Aulacomyella neogeae* Zone (lowermost Tithonian). In the California Coast Ranges, *Parvicingula s. s.* first appears in the volcano-pelagic succession at

* This qualification was suggested by Westermann (written commun., 1984) to distinguish French from English views on the subject.

Point Sal (Santa Barbara Co.; Hopson, Mattinson, and Pessagno, 1981, loc. 2) between 10.6 m (35 ft) and 11.5 m (38 ft) above the contact with the Coast Range ophiolite. Near Paskenta (Tehama Co.; Hopson, Mattinson, and Pessagno, 1981, loc. 22), *Parvicingula s. s.* occurs in upper Zone 2 strata (Great Valley Supergroup?) overlying the ophiolite breccia unit, which in turn overlies the Coast Range ophiolite. At this locality, *Parvicingula s. s.* is directly associated with *Buchia rugosa* (Fischer, 1830–1837) and forms transitional to *B. concentrica* (Sowerby, 1827). Both Jones (1975, p. 330) and Imlay (1980, p. 63) favored assigning the strata bearing *Buchia* Rouillier, 1845, to the upper Kimmeridgian. However, Imlay indicated that these strata might also be assignable to the lower Tithonian. Significantly, Lanphere (1971, p. 3210) obtained a K/Ar date of 151 ± 5 m.y. at a nearby locality from a diabase dike intruding the Coast Range ophiolite, but intruding neither the ophiolite breccia unit nor the overlying strata bearing *Parvicingula s. s.* and *Buchia rugosa.* The Decade of North American 1983 Geologic Time Scale (Palmer, 1983; Kent and Gradstein, 1985) placed the Kimmeridgian–Tithonian boundary at 152 ± 12 m.y. Harland *et al.* (1982) placed the Kimmeridgian–Tithonian boundary at 150 Ma. The data presented above suggest that the Kimmeridgian–Tithonian boundary is younger than 151 m.y. and probably should be placed at 150 Ma as suggested by Harland *et al.*

Pessagno, Blome, and Longoria (1984) concluded from their analysis of biostratigraphic data from North America, the Deep Sea Drilling Project, the Mediterranean area, and Rumania that the base of Zone 2 (= first occurrence of *Mirifusus* Pessagno, 1977a) occurs in strata equivalent to the *divisum* Standard Zone (upper lower Kimmeridgian) or to the *acanthicum* Standard Zone (lower upper Kimmeridgian) of the European Tethyan Realm. Recent studies by Pessagno and Blome demonstrate that the Zone 1–Zone 2 boundary now can be recognized in the Klamath Mountains of northwestern California (Western Klamath terrane, Smith River subterrane; Harper, 1983, loc. 1). At Harper locality 1 the Galice Formation *s. l.* rests on the Josephine ophiolite. Well-preserved, abundant upper Zone 1 Radiolaria were recovered from the Galice Formation at 3.2 m (10.5 ft) and 12.8 m (42 ft) above the sedimentary contact with the Josephine ophiolite. Lower Zone 2 Radiolaria were recovered from samples 17.5 m (58 ft) to 61.2 m (201 ft) above the contact with the ophiolite. Moreover, Saleeby *et al.* (1982) obtained a concordant U/Pb date of 157 ± 2 m.y. (on zircon) from plagiogranite within the Josephine ophiolite. In addition, these workers also obtained a concordant U/Pb date of 150 ± 2 m.y. (on zircon) from a keratophyre sill intruding the Galice Formation. The geochronometric data cited above establish that the Zone 1–Zone 2 boundary is younger than 157 Ma and older than 150 Ma. It should be noted that only Central Tethyan Radiolaria have been observed in the lower 17.5 m (58 ft) of this succession. However, Southern Boreal Radiolaria were recovered from samples 54 m (178 ft) to 61 m (201 ft) above the contact with the Josephine ophiolite.

The 157 Ma date on the Josephine ophiolite is significant in that it can be related to ammonite and bivalve biostratigraphic data as well as U/Pb geochronometric data from the nearby Rogue Valley subterrane (Western Klamath terrane) of southwestern Oregon. In the Rogue Valley subterrane Saleeby (1984) obtained a concordant U/Pb date of 157 ± 2 m.y. (on zircon) from dacitic tuff breccia in the upper several hundred meters of the Rogue Formation. Moreover, Imlay (1961) recovered the middle Oxfordian ammonite *Dichotomosphinctes* Buckman, 1926, from the lower part of the overlying Galice Formation *s. s.* in the same area. In the Submediterranean Province (European Tethyan Realm), Meléndez, Sequeiros, and Brochwicz-Lewinski (1984) demonstrated that *Dichotomosphinctes* ranges from the *antecedens* Standard Zone (*rotoides* Standard Subzone) to the *transversarium* Standard Zone (*schilli* Standard Subzone). We follow Zeiss (Enay and Meléndez, 1984, table 4) in assigning the *antecedens* Standard Zone to the lower middle Oxfordian and the *schilli* Standard Subzone to the middle part of the middle Oxfordian. *Dichotomosphinctes* is also associated with *Buchia concentrica* (Sowerby, 1827) in the lower part of the Galice. Imlay (1955, 1961, 1980) established that in North America, *B. concentrica* does not range below the first occurrence of *Amoeboceras* Hyatt, 1900. In addition, Imlay (1961, p. D-11) noted that in the Naknek Formation of Alaska, *B. concentrica* is associated with both *Amoeboceras* and *Dichotomosphinctes.* Sykes and Callomon (1979) established that *Amoeboceras* does not range below the base of the *glosense* Standard Zone (*ilovaiskii* Standard Subzone) in Great Britain (Boreal Realm). Furthermore, Zeiss (*in* Enay and Meléndez, 1984, table 4) tentatively correlated the Boreal *ilovaiskii* Standard Subzone with the Tethyan *schilli* Standard Subzone. It is apparent that this correlation is strengthened by the association of *Amoeboceras* and *Dichotomosphinctes* in the Naknek Formation of Alaska. The concurrence of *Dichotomosphinctes* and *B. concentrica* in the lower part of the Galice Formation demonstrates that this interval should be assigned to the middle part of the middle Oxfordian. The combined biostratigraphic and geochronometric data from the Rogue Formation and overlying Galice Formation therefore indicate that the middle part of the middle Oxfordian is

younger than 157 Ma. Moreover, these data indicate that the 156 Ma age for the Oxfordian–Kimmeridgian boundary advocated by Kent and Gradstein (1985) is too old. Westermann (1984) used what he termed the "scaled equal subzone method" to calculate the relative duration of Jurassic standard ammonite zones. He concluded that the middle Oxfordian represented 1.7 Ma and that the upper Oxfordian represented 2.6 Ma. If the Oxfordian–Kimmeridgian boundary is placed at 156 Ma as suggested by Kent and Gradstein, more than one third of Oxfordian time would be crowded into less than 1 million years.

(5) The high TiO_2 values of basalts associated with ophiolite-like masses at Stoneyford and Wilbur Springs indicate that these rocks are representative of ocean island basalts and are beyond the compositional range of ocean ridge basalts (Hopson, Mattinson, and Pessagno, 1981; Hopson, oral commun., 1983).

(6) Immediately noticeable in the upper half to one-third of Upper Jurassic volcano-pelagic successions above the Coast Range ophiolite (*e.g.,* Point Sal and Stanley Mountain) and in the overlying Great Valley Supergroup are the abundance and diversity of species of *Parvicingula* Pessagno, 1977a, and the low diversity of pantanelliids (see *East-central Mexico* herein). This evidence together with the abundance of *Buchia* Rouillier, 1845, in the Great Valley Supergroup indicates that these strata were deposited in the Boreal Realm (Text-figs. 2, 3). Imlay and Jones (1970, p. 319) indicated that the Upper Jurassic (upper Tithonian, *sensu* Pessagno, Blome, and Longoria, 1984) ammonite assemblage of the Great Valley Supergroup displays very strong "southern or Mediterranean" affinities. However, they noted that the *Buchia* are much more common numerically than the ammonites and are clearly indicative of a northern (Boreal) derivation. We conclude, therefore, that the upper half to one-third of the volcanogenic-pelagic succession above the Coast Range ophiolite as well as all of the overlying Great Valley Supergroup was deposited at latitudes within the Southern Boreal Province (Text-fig. 3). In contrast, the red (non-tuffaceous), manganiferous, radiolarian-bearing ribbon cherts that are interbedded with the ophiolite at Point Sal (Santa Barbara Co.), Llanada (San Benito Co.), and Paskenta (Tehama Co.) are Tethyan (Central Tethyan). At most localities these cherts are recrystallized and the radiolarians poorly preserved. However, at Paskenta a sample submitted in 1973 to the senior author by Deborah Fritz (Univ. of Texas at Austin) was found to contain a diversified, moderately well-preserved late Callovian to Oxfordian (upper Zone 1) fauna. Significantly, the nassellarian assemblage lacks *Parvicingula* Pessagno, 1977a (*sensu* Pessagno and Whalen, 1982) but contains abundant specimens of *Ristola* Pessagno and Whalen, 1982; pantanelliids, though present, are poorly preserved. The abundance of *Ristola,* together with the lack of *Parvicingula,* demonstrates that this assemblage is representative of the Central Tethyan Province (Text-fig. 2). As noted previously, the red ribbon cherts of the Franciscan Complex (Lower Jurassic to Upper Cretaceous) likewise contain a Tethyan—dominantly Central Tethyan—radiolarian assemblage.

(7) Paleomagnetic data on the Coast Range ophiolite are presently sparse. However, McWilliams and Howell (1982, p. 215) determined that the ophiolite (pillow basalts) at Stanley Mountain (Alamo Canyon, San Luis Obispo Co.) originated at 14° ± 7 north or south of the Middle to Late Jurassic paleoequator. The overlying volcanogenic-pelagic succession at this locality is 103 m (338 ft) thick (Hopson, Mattinson, and Pessagno, 1981; Pessagno, Blome, and Longoria, 1984). Investigations by Pessagno and Blome indicate that the lower 61 m (199 ft) of this section contain a Central Tethyan Zone 2 (upper Oxfordian?; Kimmeridgian, *sensu gallico*) fauna composed of *Ristola* Pessagno and Whalen, 1982, and, when well-preserved, a diversified pantanelliid assemblage. These investigations indicate further that the lower part of Zone 3 and possibly the upper portion of Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984) are missing. The interval from 62 m (204.5 ft) to below 73 m (239 ft) likewise contains a Central Tethyan upper Zone 3 (lower Tithonian) assemblage still rich in *Ristola,* but totally lacking *Parvicingula* Pessagno, 1977a; *sensu* Pessagno and Whalen, 1982. Samples from 73 m (239 ft) contain *Parvicingula* and poorly-preserved pantanelliids; these samples may be assignable to either the Northern Tethyan Province or to the Southern Boreal Province (Text-fig. 2). The interval from 80 m (261 ft) to the top of the section contains a *Parvicingula*-rich Southern Boreal assemblage assignable to upper Zone 3 (lower Tithonian) and to lower Zone 4 (basal upper Tithonian, *sensu* Pessagno, Blome, and Longoria, 1984). Well-preserved radiolarian faunas from pelagic limestones at 80 m (261 ft; Zone 3) and 101 m (330 ft; Zone 4) contain poorly-diversified pantanelliids (two or three species-level taxa; see *East-central Mexico* herein).

At Point Sal the volcanogenic–pelagic succession above the Coast Range ophiolite is only 23+ m (75+ ft) thick. Below 11 m (35 ft), the strata are somewhat recrystallized and the faunas are generally not spectacular. Sparse Central Tethyan upper Zone 1 faunas (Oxfordian to lower Kimmeridgian, *sensu gallico*) containing *Ristola* and lacking *Parvicingula* occur in the lower 4 m (14 ft) of the succession above the contact with the ophiolite. Central Tethyan Zone 2 faunas occur at 4.5 m (15 ft) and 5 m (18 ft). A sample (loc.

NSF-906) from 11 m (35 ft) assignable to lower Zone 2 (upper portion; upper Kimmeridgian) contains *Parvicingula s. l.*, no *Parvicingula s. s.*, and poorly-preserved pantanelliids. This sample may be representative of either the Northern Tethyan Province or the Southern Boreal Province. However, upper Kimmeridgian (upper Zone 2) and lower Tithonian samples (Zone 3) from 11.5 m (38 ft) and above contain definite Southern Boreal faunas. Because many of these samples (*e.g.*, locs. NSF-907, NSF-908, and NSF-909; see *Appendix*) contain well-preserved Radiolaria derived from pelagic limestone, there can be little doubt about the low diversity of the pantanelliid assemblage or the high diversity of the *Parvicingula* assemblage (with *Parvicingula s. s.*).

EAST-CENTRAL MEXICO

This area lies approximately between the latitude of Tampico to the north and Veracruz to the south. It includes an Upper Jurassic and Lower Cretaceous bathyal succession that has a direct bearing on the opening of the Gulf of Mexico, in that it lies astride the axis of sea floor spreading and rifting shown by Buffler *et al.* (1980) for the Gulf of Mexico. This deep-water segment of the Sierra Madre Oriental, referred to by Longoria (1984) as the Huayacocotla segment, is flanked to the north and south by shelf deposits characterized by evaporites and carbonates. Upper Jurassic formational units within the Huayacocotla segment of the Sierra Madre Oriental are characterized by the association of ammonites, ammonite aptychi, pectenacids, abundant Radiolaria, calpionellids, and nannoconids. The presence of calpionellids together with a molluscan assemblage of strong Mediterranean affinities indicates that this region was part of the Tethyan Realm (see Cantu Chapa, 1971; Imlay, 1980, p. 38). The radiolarian assemblage is characterized by the presence of *Parvicingula* Pessagno, 1977a (*sensu* Pessagno and Whalen, 1982), and by an abundant diversified assemblage of pantanelliids. Species of Pantanelliidae (Pessagno, 1977b; Pessagno and Blome, 1980) are considerably more abundant and diversified in the Taman Formation than they are in strata of Kimmeridgian or Tithonian age in the Boreal Realm (*e.g.*, Galice Formation, Northern California; volcanogenic-pelagic strata overlying the Coast Range ophiolite at Point Sal and Stanley Mountain). There are generally three to four times more species-level taxa present in the assemblage of the Taman Formation than there are in Boreal strata of the same age in California (Pessagno, Longoria, MacLeod, and Six [in press]). It also should be noted that the Taman Formation contains Tethyan species (*e.g.*, *Acanthocircus dicranocanthos* Squinabol, 1914), which never have been observed in the Boreal California assemblage. *A. dicranocanthos* is a Central Tethyan and Northern Tethyan species that occurs in red ribbon cherts from the Mediterranean area, Oman, the East Indies, and the Franciscan Complex (Text-fig. 3). The radiolarian assemblage of east-central Mexico thus appears to link the assemblages of the Central Tethyan Province with those of the Southern Boreal Province. This together with the Tethyan nature of the megafossil assemblage indicates that this region is representative of the Northern Tethyan Province.

Stratigraphic Summary

Taman Formation

The Taman Formation (Heim, 1926, pp. 84–89) in its type area at Taman (San Luis Potosí) includes thin- to medium-bedded, dark-gray to black, organic-rich, petroliferous micritic limestone with interbeds of black shale. Regionally, the Taman ranges in thickness from 200 m (656 ft) to 500 m (1640 ft). In its type area it can be subdivided into a lower unit comprised of predominantly medium-bedded limestone with thin shale interbeds and an upper unit consisting of thin-bedded limestone commonly associated with thicker, buff-weathering black shale intervals (upper portion = lower part of Pimienta Formation of Cantu Chapa, 1971). Limestone nodules are prevalent in the upper part of the lower member and in the upper member. The Taman Formation rests conformably on the black, commonly phyllitic shale of the "Santiago" formation (Callovian to Oxfordian) and beneath the thin-bedded chert, limestone, and tuff of the Pimienta Formation (upper Tithonian(?); Berriasian).

The Taman Formation, as defined above in its type area, includes early Kimmeridgian to late Tithonian strata. It encompasses (in ascending order) the *Ataxioceras, Idoceras, Glochiceras* gr. *fialar, Virgatosphinctes mexicanus–Aulacomyella neogeae,* and *Mazapilites* zones of Cantu Chapa (1971) and radiolarian zones 1 (upper part), 2, 3, and 4 (lower part) (Pessagno, Blome, and Longoria, 1984). It should be noted that the base of Zone 4 (upper Tithonian) corresponds closely to the first occurrence of *Crassicollaria intermedia* (Durand Delga, 1957) and occurs below the top of the lower Taman in the Taman–Tamazunchale area (San Luis Potosí). According to Cantu Chapa (1971) the top of the *V. mexicanus–A. neogeae* Zone corresponds to the top of what we refer to as lower Taman (= Taman Formation and part of Pimienta Formation of Cantu Chapa, 1971) whereas the base of the *Mazapilites* Zone corresponds to the base of the upper Taman (= Pimienta Formation [in part] of Cantu Chapa, 1971). However, the senior author (May, 1985) collected *Aulacomyella neogeae* Imlay, 1940, 30 m

(96.8 ft) above the contact between the lower and upper Taman at Barrio de Guadalupe (San Luis Potosí; loc. MX 85-35). It would appear, therefore, that the upper part of the *V. mexicanus–A. neogeae* Zone overlaps the lower part of the *Mazapilites* Zone. This and other problems pertaining to Cantu Chapa's ammonite zonation for the Tithonian are discussed in detail by Pessagno, Longoria, MacLeod, and Six [in press].

Vizcaino Peninsula, Baja California Sur, Mexico

The geology of this complex area is still poorly known in spite of recent efforts by workers such as Barnes (1982). It is difficult to ascertain at the moment whether or not displaced terranes are present in this region. The presence of common *Buchia* Rouillier, 1845, within the Eugenia Formation (upper Tithonian to Aptian) together with Boreal foraminiferal faunas in the overlying Valle Formation (Albian to Turonian or younger) suggests that these strata were deposited within the Boreal Realm. Curiously, Upper Cretaceous planktonic foraminifera from the Valle Formation (Longoria, oral commun., 1983) are more similar to those described by Douglas (1969) from northern California than they are to those described by Bandy (1951) and Sliter (1968) from southern California. Well-preserved Upper Jurassic and Cretaceous Radiolaria from the Eugenia and Asuncion formations (Davila, 1986) are quite similar to those described by Pessagno (1976, 1977a, 1977b) and by Pessagno, Blome, and Longoria (1984) from California, and are definitely Southern Boreal in aspect. In general, the radiolarian faunas are not as diversified as those from California. Furthermore, a well-preserved late Pliensbachian radiolarian assemblage extracted from limestone in the sandstone member of the San Hipólito Formation (see below) is poorly diversified (including pantanelliids) and appears to be more representative of the Boreal Realm. Radiolaria extracted from Upper Triassic cherts in the San Hipólito Formation are not as well preserved. However, many species present in the Karnian–Norian assemblage of the San Hipólito Formation are not represented in coeval Tethyan strata in the Queen Charlotte Islands and east-central Oregon (Pessagno, Finch, and Abbott, 1979; Pessagno and Blome, 1980; Blome, 1984a).

Stratigraphic Summary

San Hipólito Formation

The San Hipólito Formation (Mina, 1957) at its type locality at Punta San Hipólito includes 2400 m (7848 ft) of section. Finch and Abbott (1977) divided the San Hipólito Formation into four informal members. In ascending order these are (1) a chert member; (2) a limestone member; (3) a breccia member; and (4) a sandstone member. The San Hipólito Formation rests conformably on pillow basalts (andesitic basalts?); the top of the unit is not exposed in the area around Punta San Hipólito. Triassic zonal terminology follows that of Blome (1984a).

Chert Member.—The chert member includes up to 245 m (801 ft) of green to red tuffaceous cherts with subordinate amounts of volcanic sandstone and conglomerate. Pectenacids (e.g., *Halobia* Bronn, 1830) and abundant Radiolaria occur throughout much of this unit. Pessagno, Finch, and Abbott (1979) indicated that the lower 101 m (330 ft) of the chert member are assignable to the *Capnodoce* Zone (upper Karnian?; lower to upper middle Norian). The boundary between the overlying *Betraccium* Zone, *Pantanellium silberlingi* Subzone (upper middle Norian; upper Norian?) occurs between 100.8 m (330 ft) and 114.2 m (373 ft). All but the uppermost 5 m (16 ft) of the upper 61 m (201 ft) of the chert member are assignable to the *P. silberlingi* Subzone.

Limestone Member.—This unit includes up to 209 m (687 ft) of alternating beds of limestone and volcaniclastic sandstone, which rest conformably on the chert member. Limestone predominates in the upper half of the limestone member, whereas sandstone predominates in the lower half of the unit. *Monotis* sp. cf. *M. subcircularis* Gabb, 1864, has been identified by Dr. N. J. Silberling (U. S. Geological Survey, Denver, CO) from the uppermost part of the limestone member. Poorly-preserved calcified Radiolaria occur throughout the limestone member.

Breccia Member.—The breccia member is a lenticular mass with a maximum thickness of 105 m (343 ft). It consists of large blocks of neritic limestone set in a matrix of volcanic litharenite. The breccia member rests disconformably on the limestone member. Limestone boulders contain corals, coralline algae, and benthonic foraminifera. No Radiolaria are presently known from this member. Because Upper Triassic Radiolaria occur in the basal portion of the sandstone member (see below), the breccia member can be assigned to the upper Norian.

Sandstone Member.—According to Finch and Abbott (1977), the sandstone member has a maximum thickness of 1840 m (6017 ft) and consists of light-gray to brown, volcaniclastic sandstone and siltstone, tuff, conglomerate, and silty tuffaceous limestone. This unit rests conformably(?) on the underlying breccia member. No megafossils have been observed to date; however, Radiolaria are abundant and well preserved in tuffaceous, bedded limestone strata and in limestone nodules. Whalen has recovered Upper Triassic Radi-

olaria 13 m (42 ft) and 19 m (62 ft) above the base of the sandstone member and Lower Jurassic (upper Pliensbachian, Toarcian?) Radiolaria were recovered from 300 m (984 ft) and 400 m (1312 ft) above the base of the sandstone member.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

Pessagno, Blome, and Longoria (1984, p. 21) noted that there are radical differences in the concept of morphospecies among radiolarian specialists. They stated

> This, to a large degree, depends on whether on one is a Cenozoic or a Mesozoic specialist and furthermore, it appears to be related to the mode of illustrating and studying radiolarian taxa. Most Cenozoic Radiolaria have tests comprised of opaline silica. When specimens are properly cleaned, their internal and external features are readily discernible and can be easily illustrated using transmitted light optics. Few, if any, Mesozoic Radiolaria have tests comprised of opaline silica. Their tests, instead, have been replaced by quartz, chalcedony, smectite, pyrite, limonite, and calcite. Even specimens whose tests are still siliceous are often difficult to photograph with transmitted light optics simply because test walls are not sufficiently hyaline.
>
> Whereas transmitted light optics are still the primary tool of the Cenozoic specialist, the scanning electron microscope by necessity has become the primary tool of the Mesozoic specialist. Because the scanning electron microscope is capable of recording the minutest details of radiolarian morphology, students of Mesozoic Radiolaria are presented with a wealth of morphological data. Taxa are therefore described in more detail than would be normal utilizing transmitted light optics. As a result, Cenozoic specialists tend to be regarded by Mesozoic specialists as ultra 'lumpers' and most Mesozoic specialists are regarded by Cenozoic specialists as ultra 'splitters'.

Mesozoic and Cenozoic workers now agree that much of the classification utilized by Haeckel (1887) is highly artificial in character and needs to be replaced by a more phylogenetic classification (see Riedel, 1971; Pessagno, 1977c). Unfortunately, Haeckel's classification was based largely on the geometry or shape of the radiolarian test. The senior author believes that to obtain a more phylogenetic classification one must consider how the radiolarian test is constructed. This is particularly pertinent at the family and superfamily levels. Such a thesis is reflected in reports by Pessagno (1973), Pessagno and Blome (1980), Baumgartner (1980a), Pessagno and Whalen (1982), and Blome (1983). Hopefully, it is reflected in this report (see *Test Construction* below).

In this section the designation USNM indicates that a type specimen has been deposited at the U. S. National Museum of Natural History, Smithsonian Institution, Washington, DC, and has been assigned a catalogue number. Holotypes are isolated on one-hole cardboard slides bearing a USNM catalogue number; paratypes deposited at the U. S. National Museum are mounted in HYRAX* or CAEDAX** on a glass slide and also bear a USNM catalogue number. Paratypes deposited in the Pessagno Collection are isolated on one-hole cardboard slides.

New taxa described in this report are illustrated by means of scanning electron micrographs. When preservation permits, transmitted light photomicrographs are also utilized (see Pl. 11).

Measurements are made with micrometers implanted in the oculars of either a stereoscopic microscope or a transmitted light microscope. All measurements have been converted from millimeters to μm (1 μm = 10^{-6} m).

TEST CONSTRUCTION

Two families, the Farcidae, n. fam., and the Hilarisiregidae Takemura and Nakaseko (1982), display cephalic skeletal elements that include the following components: primary and secondary left lateral bars; primary and secondary right lateral bars; vertical bar; and apical bar (Pl. 1, figs. 3, 11, 17, 18). Significantly, in both families the dorsal bar is absent (see Takemura and Nakaseko, 1982). The Ultranaporidae likewise have a similar array of cyrtoid cephalic skeletal elements (Pl. 1, figs. 8, 15), but differ in possessing a dorsal bar. This latter arrangement is common to most Mesozoic Nassellariina. The Farcidae and Hilarisiregidae appear to show an alignment of their four feet with the two primary lateral bars and two secondary lateral bars (Pl. 1, figs. 11, 17). There is no direct structural connection on most specimens between the feet and the opposing cephalic skeletal elements. The exception appears to be one unusual specimen of the farcid genus *Rolumbus,* n. gen., which displays a direct connection between the primary and secondary lateral bars and the proximal extensions of the triradiate feet (Pl. 1, figs. 1, 16). In *Hilarisirex* Takemura and Nakaseko, 1982, one sees an alignment of the feet (Pl. 1, fig. 17) with the primary and secondary lateral bars. The feet are not connected directly to the cephalic skeletal elements but are continuous with the sides of the A-frames (Pl. 1, figs. 13, 17). In the case of the Ultranaporidae Pessagno, 1977b, one foot of *Napora* Pessagno, 1977a, is aligned with the dorsal bar and the two remaining feet are aligned with the primary left lateral and right lateral bars. Many, but not all, species of *Napora* show an alignment of pore frames between the proximal portions of the feet and cephalic skeletal elements both internally and externally (e.g., Pl. 6, figs. 15, 20; Pl. 9, fig. 18). Where this lineation is visible externally, it

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* HYRAX is a product of Custom Research and Development, Auburn, CA.

** CAEDAX is a product of EM Laboratories, Elmsford, NY.

appears to be directly aligned with the outermost longitudinal ridges of a given triradiate foot. *Jacus* De Wever, 1982, displays the same sort of arrangement of cephalic skeletal elements and opposing feet displayed by *Napora.* De Wever's illustration of the interior of *Jacus coronatus* De Wever, 1982 (pl. 12, fig. 3) appears to indicate an alignment of pore frames.

It is suggested here that the arrangement of cephalic skeletal elements noted above may serve as a template for test secretion, at least with monocyrtid, dicyrtid, and tricyrtid Nassellariina with prominent triradiate feet. This hypothesis needs to be tested, however, through the study of both fossil and Recent Radiolaria.

Both the Farcidae, n. fam., and the Ultranaporidae Pessagno, 1977b, seem to share a method of pore frame secretion that ultimately results in test thickening. In viewing either the farcid or the ultranaporid test from its interior, one immediately notices that the pore frames are smooth and flattened with little or no relief (Pl. 1, figs. 12, 15; Pl. 7, figs. 5, 22). However, viewed from the test exterior, the pore frames are much deeper, commonly nodose, and show considerable relief (*e.g.,* Pl. 7, figs. 19, 22). These observations suggest that test thickening occurred via the accretion of microgranular silica (probably in a lamellar mode) around pore frame rims on the exterior, but not the interior, of the test. Because all of the thoracic pore frames of a given specimen of *Napora* are of approximately the same depth, it is suggested that each time a lamella of microgranular silica was secreted, it covered the entire surface of the thorax—thus resulting in the equal development of the pore frames. This at least appears to be the case with *Napora, Farcus,* n. gen., and *Rolumbus,* n. gen. However, the pore frames of *Jacus* De Wever, 1982, are typically inset between massive ridges and show considerable differences in relief. Obviously, the genetic code governing the accretion of silica on the pore frames of *Jacus* differed considerably from that of *Napora, Farcus,* and *Rolumbus.*

Thickening of both cephalic and thoracic pore frames proceeded in the manner cited above until the proximal portion of the test was covered by an outer layer of microgranular silica. On well-preserved specimens this layer is thin and commonly does not obscure pore frame rims. The thinness of this layer, as well as its superposition on cephalic and proximal thoracic pore frames, suggests that it was formed at a late stage in ontogeny. The thin, fragile nature of the tubular, velum-like structure extending from the aperture (mouth) of the farcid genus *Rolumbus,* n. gen., and *Jacus* De Wever, 1982, as well as its distal position, suggests that this structure formed at a very late stage of ontogeny (Pl. 5, fig. 17). Via the model proposed above it is assumed that lamellae of microgranular silica are added to the horn(s) and feet, strengthening and lengthening these structures at the same time that pore frame thickening occurred.

The mode of test secretion among the Hilarisiregidae differs in part from that of the Farcidae and Ultranaporidae. The cephalic and thoracic walls of *Hilarisirex* Takemura and Nakaseko, 1982, consist of a single layer of thick massive pore frames that is covered by a thin layer of microgranular silica. Pore frame rims often project through this thin layer (Pl. 8, figs. 6, 14), suggesting that the pore frames are high in relief on the test exterior and were formed in a fashion similar to that proposed for the Farcidae and Ultranaporidae. However, the structure of the abdomen of *Hilarisirex* appears to be considerably different. The abdominal walls consist of an inner latticed layer of flattened pore frames (Pl. 8, figs. 13–15, 17–19) overlain by an outer latticed layer formed by vermicular ridges. The degree of development of the outer vermicular, latticed layer is variable even with members of the same species. In some cases it can be quite dense while in others it is barely noticeable (see Pl. 8, fig. 14; Pl. 8, fig. 19). It is likely that this outer vermicular layer was secreted at a late stage in ontogeny and supplanted the normal mode of pore frame thickening and strengthening (*e.g.,* in *Rolumbus,* n. gen.). *Diceratigalea* Takemura and Nakaseko, 1982, differs from *Hilarisirex* and other forms assignable to the Hilarisiregidae in the structure of its abdominal wall. *Diceratigalea* has not been observed in our North American Jurassic material. However, from our analysis of the illustrations presented by Takemura and Nakaseko (1982, pl. 72, figs. 1–2; pl. 73, fig. 1), this genus appears to possess weakly-developed A-frames and pore frame structure resembling that of *Rolumbus,* n. gen., *Farcus,* n. gen., and *Napora* Pessagno, 1977a. Except for the fact that the test is tricyrtid and possesses typical hilarisiregid-type partitions at the base and top of the abdomen, this form appears more closely-related to *Rolumbus* (see Takemura and Nakaseko, 1982, pl. 72, figs. 2b, 2c and *Hilarisirex*).

Suborder **NASSELLARIINA** Ehrenberg, 1875

Family **FARCIDAE**, new family

Type genus.—*Farcus,* new genus.

Diagnosis.—Test dicyrtid with single layer of latticed meshwork on both cephalis and thorax. Latticed layer of cephalis and occasionally proximal portion of thorax covered by thin outer layer of microgranular silica. Cephalis large, hemispherical with one horn (e.g., *Farcus,* n. gen.), or two horns (e.g., *Rolumbus,* n. gen.), which are triradiate in axial section. Cephalic skeletal elements cyrtoid, including vertical bar, primary left

lateral bar, primary right lateral bar, median bar, secondary left lateral bar, secondary right lateral bar, and apical bar (dorsal bar absent). Thorax large, inflated, with four (rarely five) feet that are triradiate in axial section. Four feet opposed to two primary lateral and two secondary lateral bars; fifth foot, if present, opposed to vertical bar. Base of thorax hemispherical with centrally-placed circular aperture (mouth) that has an imperforate rim. Thorax with (e.g., *Rolumbus,* n. gen.) or without (e.g., *Farcus,* n. gen.) fragile tubular, velum-like structure extending distally from aperture (mouth) of well-preserved specimens.

Remarks.—The Farcidae, n. fam., differ from the Hilarisiregidae Takemura and Nakaseko, 1982, by having a dicyrtid rather than a tricyrtid test, by always having a single layer of latticed meshwork, and by always lacking A-frames. Furthermore, where the feet of the hilarisiregid test are continuous proximally with the A-frames, those of the farcid test commonly merge with the thoracic wall (Pl. 1, figs. 3, 11, 18; 12, 14). A single exception is one unusual specimen of *Rolumbus* sp. (Pl. 1, figs. 1, 16). On this specimen the two primary and secondary lateral bars unite directly with the proximal extensions of the feet. In this case, the innermost longitudinal ridge of a given proximal extension of a foot joins an opposing lateral bar.

In spite of the differences cited above it is probable that the Farcidae gave rise to the Hilarisiregidae. The two families display the same configuration of cephalic skeletal elements (see Pl. 1, figs. 12, 14; Pl. 1, fig. 9). Noticeable in particular in both families is the absence of a dorsal bar. It is likely that *Rolumbus* sp. gave rise to either *Hilarisirex* sp. or *Diceratigalea* sp., through the acquisition of a tricyrtid test. In both cases this evolutionary feat was most likely accomplished through the development of A-frames on the distal nine-tenths of the thorax of *Rolumbus* and through the development of flattened partitions at the top and the base of A-frames (see Hilarisiregidae herein). As a result, the thorax of either *Hilarisirex* Takemura and Nakaseko, 1982, or *Diceratigalea* Takemura and Nakaseko, 1982, became reduced at the expense of the abdomen and its four characteristic A-frames. Because *Diceratigalea* displays similar pore frame structure to that of *Rolumbus* (see *Test Construction* herein) and weakly-developed A-frames, it is likely that *Rolumbus* gave rise to *Diceratigalea* and that *Diceratigalea* in turn gave rise to *Hilarisirex.* The latter evolutionary feat was most likely accomplished through the strengthening of the A-frames and the acquisition of two layers of latticed meshwork (see *Test Construction,* pp. 21–22 and Hilarisiregidae, pp. 29–30).

Range.—Lower Jurassic: upper Pliensbachian to upper Toarcian.

Occurrence.—Nicely Formation, Hyde Formation, and the Warm Springs Member of the Snowshoe Formation, east-central Oregon. San Hipólito Formation, Baja California Sur. Tethyan Realm; ? Boreal Realm.

Genus **FARCUS**, new genus

Type species.—*Farcus graylockensis,* n. sp.

Etymology of name.—*Farcus* (masc.) is a name formed by an arbitrary combination of letters (ICZN, 1964, Appendix D, pt. VI, Recommendation 4, p. 113).

Diagnosis.—Test as with family but possessing a single, massive apical horn that is attached to the apical bar. Thorax lacking tubular, velum-like structure distally.

Remarks.—*Farcus,* n. gen., is compared to *Rolumbus,* n. gen., under the latter genus.

Range.—Lower Jurassic: upper Pliensbachian to middle Toarcian.

Occurrence.—Nicely Formation, Hyde Formation, and Warm Springs Member of the Snowshoe Formation, east-central Oregon. Sandstone member, San Hipólito Formation, Baja California Sur, Mexico. Tethyan Realm, ?Boreal Realm.

Farcus asperoensis, new species

Plate 3, figures 12, 16, 17, 21; Plate 11, figure 9

Etymology.—This species is named for Pico Aspero, which is located east of its type area.

Diagnosis.— Cephalis medium-sized, hemispherical, with single, massive triradiate horn; cephalis commonly covered by layer of microgranular silica. Horn triradiate in axial section with rounded, longitudinal ridges and narrow grooves. Thorax with small, polygonal pore frames, commonly partially covered by a thin layer of microgranular silica. Four feet, medium-sized, triradiate in axial section with narrow, rounded longitudinal ridges and broad grooves. Four feet commonly attached to base of thorax, although on some specimens two of the feet are attached part way up the thorax. Circular mouth surrounded by imperforate rim.

Remarks.—*Farcus asperoensis,* n. sp., differs from other species of *Farcus* by the nature of the distinctive imperforate rim surrounding the mouth. An undescribed species of *Farcus* (Pl. 11, fig. 14) from the Hyde Formation of east-central Oregon possesses an elongated thorax and massive horn similar to those of *F. asperoensis,* n. sp.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	20	22.3 (9)	30 (9)	18 (9)
length of thorax	80	80 (9)	90 (9)	70 (9)
width of thorax at top	48	50.5 (9)	64 (9)	43 (9)
width of thorax at base	50	61.2 (8)	70 (8)	50 (8)
length of horn	48	64.6 (9)	80 (9)	48 (9)
width of horn at base	13	20.4 (9)	25 (9)	13 (9)
length of foot (maximum)	32	61.3 (9)	80 (9)	32 (9)

Type locality.—SH-412-14 (see *Appendix*).

Deposition of types.—Holotype: USNM 379276; paratypes: USNM 379277 and Pessagno Collection.

Range.—Lower Jurassic: upper Pliensbachian so far as known (see Text-fig. 7).

Occurrence.—Sandstone member, San Hipólito Formation, Baja California Sur. ?Boreal Realm (see Text-fig. 5).

Farcus graylockensis, new species
Plate 2, figures 4, 6–8, 12, 15

Etymology.—*Farcus graylockensis,* n. sp., is named for Graylock Butte, which is located north of its type locality.

Diagnosis.—Single horn wide, massive, triradiate in axial section; horn comprised of three wide, wedge-shaped grooves alternating with three wide, rounded ridges. Thorax with massive, uniformly-sized tetragonal and pentagonal pore frames. Feet moderately long, triradiate in axial section; three longitudinal grooves deep, wider proximally than distally, wedging out distally; three longitudinal ridges rounded, becoming progressively narrower distally.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	25.7 (10)	30 (10)	20 (10)
length of thorax	100	92.5 (10)	100 (10)	75 (10)
width of thorax at top	62.5	63.7 (10)	87.5 (10)	50 (10)
width of thorax at base	112.5	106.2 (10)	120 (10)	100 (10)
length of horn	70	72.7 (10)	87.5 (10)	62.5 (10)
width of horn at base	25	23.5 (10)	25 (10)	20 (10)
length of foot (maximum)	95	96.5 (10)	125 (10)	75 (10)

Remarks.—This species differs from similar forms among the Hilarisiregidae Takemura and Nakaseko, 1982, by possessing a dicyrtid test, and considerably different wall structure (see Pl. 1, figs. 4, 5, 10).

Type locality.—OR-536 (see *Appendix*).

Deposition of types.—Holotype: USNM 379278; paratypes: USNM 379279 and Pessagno Collection.

Range.—Lower Jurassic: upper Pliensbachian (Text-fig. 7).

Occurrence.—Nicely Formation of east-central Oregon. Tethyan Realm (Text-fig. 5).

Farcus species A
Plate 3, figure 4

Remarks.—*Farcus* sp. A differs from *F. graylockensis*, n. sp., by having a ridgelike structure around the basal part of thorax.

Range and occurrence.—Lower Jurassic: upper Pliensbachian to middle Toarcian. The Nicely Formation, east-central Oregon, loc. OR-536. Tethyan Realm.

Farcus species B
Plate 3, figure 13

Remarks.— Similar to *F. graylockensis,* n. sp., but possessing five feet.

Range and occurrence.—Same as for *Farcus* sp. A.

Farcus(?) species C
Plate 5, figures 7, 10

Remarks.—The massive horn and feet and subspherical thorax of *Farcus* (?) sp. C distinguish it from *Farcus asperoensis.*

Range and occurrence.—Sandstone member, San Hipólito Formation, loc. BPW-30; upper Pliensbachian.

Text-figure 5.—Occurrence of Lower Jurassic Nassellariina (Ultranaporidae Pessagno, 1977b; Farcidae, new family; and Hilarisiregidae Takemura and Nakaseko, 1982) in east-central Oregon, California, the Queen Charlotte Islands, and Baja California Sur.

X = Occurrence of taxa; **QC** = Queen Charlotte Islands; **OR** = east-central Oregon; **NSF** = California Coast Ranges; **BPW★** = Vizcaino Peninsula, Baja California Sur (Sample SH-412-14 included in BPW★ category on occurrence chart).

1 = Nicely Formation; **2** = Hyde Formation; **3** = Snowshoe Formation; **4** = Franciscan Complex; **5** = San Hipólito Formation, "sandstone member".

A = lower Toarcian; **B** = upper Pliensbachian; **C** = upper Pliensbachian?; lower Toarcian; upper Toarcian?; **D** = upper Toarcian.

FAUNAL REALMS	Tethyan																	Boreal ?
CHRONOSTRATIGRAPHIC UNITS	Sinemurian	Pliensbachian	A	B	C	D							Pliensbachian				upper Pliensbachian	
	upper	lower																
LITHOSTRATIGRAPHIC UNITS	Kunga Fm.	Maude Fm.	1	2	3								4				5	
	QC							OR					NSF			BPW*		
SAMPLE LOCALITIES	675	590A	676	532	534	537	622	536	600	589	958	959	960	14	412–14	28	30	
Farcus asperoensis, n. sp.														X	X			
Farcus graylockensis, n. sp.								X										
Farcus sp.							X	X	X	X				X	X	X	X	
Rolumbus gastili, n. sp.																	X	
Rolumbus halseyensis, n. sp.														X	X			
Rolumbus hamiltoni, n. sp.								X										
Rolumbus mirus, n. sp.									X									
Rolumbus venustus, n. sp.								X	X	X								
Rolumbus sp.								X	X	X				X	X	X	X	
Jacus reiferensis, n. sp.																X	X	
Jacus (?) sandspitensis, n. sp.				X	X													
Jacus (?) sp. aff. J. (?) sandspitensis, n. sp.													X					
Jacus sp./Jacus (?) sp.				X	X	X	X	X	X	X	X	X	X		X	X	X	
Napora cerromesaensis, n. sp.																	X	
Napora (?) graybayensis, n. sp.	X	X	X															
Napora insolita, n. sp.								X	X	X								
Napora mitrata, n. sp.									X									
Napora morganensis, n. sp.								X										
Napora sp.								X	X	X	X			X			X	

Genus **ROLUMBUS**, new genus

Type species.—*Rolumbus mirus* Pessagno, Whalen, and Yeh, n. sp.

Etymology.— *Rolumbus* (masc.) is a name formed by an arbitrary combination of letters (ICZN, 1964, Appendix D, pt. VI, Recommendation 4, p. 113).

Diagnosis.—Test as with family but possessing two massive horns: a vertical horn attached to the vertical bar and an apical horn attached to the apical bar. Tubular, velum-like structure extending from base of thorax on well-preserved specimens (Pl. 1, fig. 2).

Remarks.—*Rolumbus,* n. gen., differs from *Hilarisirex* Takemura and Nakaseko, 1982, by being dicyrtid rather than tricyrtid, by having only a single layer of latticed meshwork, and by lacking A-frames. It differs from *Farcus,* n. gen., by having two rather than one horn and by having a tubular, velum-like structure extending from the base of the thorax (see *Rolumbus* sp., Pl. 1, fig. 2).

Range.—Lower Jurassic: upper Pliensbachian to middle Toarcian.

Occurrence.—Nicely Formation, Hyde Formation, and Warm Springs Member of the Snowshoe Formation, east-central Oregon. San Hipólito Formation, Baja California Sur. Tethyan Realm. ?Boreal Realm.

Rolumbus gastili, new species
Plate 4, figures 1, 5, 6, 9, 12–14

Etymology.—This species is named for R. Gordon Gastil (San Diego State University, San Diego, CA) in honor of his immense contributions to our understanding of the geology of Baja California.

Diagnosis.—Cephalis large, dome-shaped with an irregular layer of microgranular silica; pore frames may be exposed at base of cephalis. Horns straight; apical horn longer than vertical horn; horns triradiate in axial section with narrow, rounded, longitudinal ridges and narrow grooves; discontinuous, narrow ridges may lie between three main ridges, extending part way up horn. Thorax with very irregularly-sized and -shaped tetragonal and pentagonal pore frames; pore frames arranged in poorly-defined transverse rows separated by ridges. Four feet of medium length, triradiate in axial section with narrow, rounded ridges and broad grooves. Mouth circular in outline. Tubular, velum-like structure may be preserved at base of thorax.

Remarks.—The moderately-developed transverse ridges of *Rolumbus gastili,* n. sp., distinguish it from *Rolumbus halseyensis,* n. sp.

Measurements (in μm).—Numbers of specimens measured are in parentheses, X = broken.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	30	25.3 (9)	30 (9)	20 (9)
length of thorax	85	76.8 (8)	90 (8)	65 (8)
width of thorax at top	55	49.8 (9)	58 (9)	40 (9)
width of thorax at base	100	97.3 (9)	110 (9)	75 (9)
length of apical horn	90	88.3 (9)	108 (9)	60 (9)
length of vertical horn	20X	52.6 (3)	60 (3)	48 (3)
distance between horn tips	150	126.6 (3)	140 (3)	120 (3)
length of foot (maximum)	80	69.2 (7)	80 (7)	50 (7)

Type locality.—BPW-30 (see *Appendix*).

Deposition of types.—Holotype: USNM 379280; paratypes: USNM 379281 and Pessagno Collection.

Range.—Lower Jurassic: upper Pliensbachian so far as known (Text-fig. 7).

Occurrence.—Sandstone member, San Hipólito Formation, Baja California Sur. ? Boreal Realm (Text-fig. 5).

Rolumbus hamiltoni, new species
Plate 3, figures 5, 7, 9, 14

Etymology.—This species is named for Dr. Warren G. Hamilton (U. S. Geological Survey, Denver, CO), in honor of his many contributions to the geology of western North America.

Diagnosis.—Cephalis with two massive, straight, triradiate horns comprised of three wide, rounded longitudinal ridges alternating with three narrow deep grooves; horns widely separated; vertical horn shorter than apical horn. Thorax with large, massive tetragonal and pentagonal pore frames. Four feet triradiate in axial section, with three wide, rounded longitudinal ridges alternating with three deep longitudinal grooves.

Remarks.—*Rolumbus hamiltoni,* n. sp., differs from *Rolumbus mirus,* n. sp., by having shorter, more massive horns and feet with wider ridges and grooves, by having a thorax with more massive, more uniformly-shaped pore frames, and by having an apical horn that is longer than the vertical horn.

FAUNAL PROVINCES	Northern Tethyan	So. Boreal	Northern Tethyan	So. Boreal
CHRONOSTRATIGRAPHIC UNITS	MIDDLE JURASSIC		UPPER JURASSIC	
	Aalenian ? / Bajocian (lower, upper) / Bathonian (upper) / Callovian		Kimmeridgian (lower, upper) / Tithonian (lower, upper) / up. Kimmer. / lower Tithonian	
LITHOSTRATIGRAPHIC UNITS	Snowshoe Formation	1	Taman Formation	2
SAMPLE LOCALITIES	OR		MX	NSF

	593	580	555	594	595	554	516	513	549C	549A	549B	550C	501A	501B	501C	530	82-3	82-6	82-8	82-15	82-16	82-17	81-54	82-19	82-20	82-37	907	908	909
Hilarisirex inflatus, n. sp.													X	X	X														
Hilarisirex oregonensis, n. sp.													X	X	X														
Hilarisirex sp.		X		X		X			X		X																X		
Napora antelopensis, n. sp.													X	X	X	X													
Napora baumgartneri, n. sp.			X	X	X	X																							
Napora bearensis, n. sp.											X																		
Napora bona, n. sp.		X																											
Napora boneti, n. sp.																			X	X									
Napora browni, n. sp.		X																											
Napora bukryi Pessagno																											X	X	
Napora burckhardti, n. sp.																						X	X	X	X				
Napora cosmica, n. sp.								X																					
Napora sp. aff. N. cosmica, n. sp.		X																											
Napora deweveri Baumgartner																							X		X				
Napora sp. cf. N. deweveri Baumgartner																							X		X				
Napora fructuosa, n. sp.	X																												
Napora heimi, n. sp.																						X	X	X	X				
Napora sp. aff. N. heimi, n. sp.																							X						
Napora horrida, n. sp.			X																										
Napora izeensis, n. sp.													X	X	X														
Napora lospensis Pessagno																											X	X	X
Napora maritima, n. sp.			X																										
Napora moctezumaensis, n. sp.																			X										
Napora sp. aff. N. moctezumaensis, n. sp.																			X										
Napora opaca, n. sp.				X	X																								
Napora tumultuosa, n. sp.													X	X	X														
Napora turgida, n. sp.			X	X																									
Napora vegaensis, n. sp.																			X										
Napora sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Text-figure 6.—Occurrence of Middle and Upper Jurassic Nassellariina (Ultranaporidae Pessagno, 1977b; Hilarsiregidae Takemura and Nakaseko, 1982) in east-central Oregon, California, and east-central Mexico.

X = Occurrence of taxa; **OR** = east-central Oregon; **MX** = eastern Mexico; **NSF** = California Coast Ranges.

1 = Lonesome Formation; **2** = Volcanogenic-pelagic strata above Coast Range ophiolite.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	37.5	26.7 (7)	37.5 (7)	25 (7)
length of thorax	125	114.2 (7)	125 (7)	100 (7)
width of thorax at top	50	50 (7)	50 (7)	50 (7)
width of thorax at base	137.5	99.6 (7)	137.5 (7)	100 (7)
length of apical horn	75	85.3 (7)	100 (7)	75 (7)
length of vertical horn	50	57.5 (5)	75 (5)	50 (5)
distance between horn tips	100	122.5 (5)	150 (5)	100 (5)
length of foot (maximum)	125	118.6 (6)	150 (6)	100 (6)

Type locality.—OR-536 (see *Appendix*).

Deposition of types.—Holotype: USNM 379282; paratypes: USNM 379283 and Pessagno Collection.

Range.—Lower Jurassic: upper Pliensbachian (Text-fig. 7).

Occurrence.—Nicely Formation, east-central Oregon. Tethyan Realm (Text-fig. 5).

Rolumbus halseyensis, new species
Plate 3, figures 1, 6, 18, 19

Etymology.—This species is named for Monte Halsey, which is located southeast of its type area.

Diagnosis.—Cephalis large, hemispherical, with layer of microgranular silica and small nodes. Horns straight to slightly curved downward, apical horn much larger than vertical horn; horns triradiate in axial section with narrow, rounded, longitudinal ridges and broad grooves; small pores may be open at base of horns. Thorax with small tetragonal and pentagonal pore frames, commonly obscured by layer of microgranular silica?; pore frames arranged in poorly-defined transverse rows separated by transverse ridges. Four feet of moderate length, triradiate in axial section with narrow, rounded ridges and broad grooves. Mouth circular in outline. Tubular velum-like structure commonly extending from base of thorax.

Remarks.—This species is compared to *Rolumbus gastili,* n. sp., under the latter species.

Measurements (in μm).—Numbers of specimens measured are in parentheses, X = broken.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	35	27.1 (6)	35 (6)	15 (6)
length of thorax	55	59.6 (6)	80 (6)	50 (6)
width of thorax at top	60	49.8 (6)	55 (6)	44 (6)
width of thorax at base	90	75.8 (6)	90 (6)	55 (6)
length of apical horn	82	79 (4)	100 (4)	54 (4)
length of vertical horn	44	43.6 (5)	58 (5)	28 (5)
distance between horn tips	155	131.2 (4)	152 (4)	98 (4)
length of foot (maximum)	50X	55 (4)	90 (4)	30X (4)

Type locality.—SH-412-14 (see *Appendix*).

Deposition of types.—Holotype: USNM 379353; paratypes: USNM 379354 and Pessagno Collection.

Range.—Lower Jurassic: upper Pliensbachian so far as known (Text-fig. 7).

Occurrence.—Sandstone member, San Hipólito Formation, Baja California Sur, ? Boreal Realm (Text-fig. 5).

Rolumbus mirus, new species
Plate 5, figures 1, 11, 16, 17; Plate 11, figures 15, 19

Etymology.—(L.) *mirus* = wonderful, astonishing.

Diagnosis.—Cephalis hemispherical, imperforate, with two slender, straight, triradiate horns connected to apical and vertical bars; horns comprised of three narrow ridges alternating with three narrow grooves; vertical horn slightly shorter than apical horn. Thorax lobulate with wall thicker proximally; thorax and thoracic velum with mixture of variably-sized triangular (rare), tetragonal (rare), pentagonal and hexagonal pore frames with narrow rims. Four feet slender, triradiate with three narrow ridges alternating with three wide grooves, grooves about twice the width of ridges; feet extending out from just below the middle part of thorax and internally aligned with four cephalic skeletal elements (two primary right lateral and two secondary left lateral bars). Aperture (mouth) circular in outline with imperforate rim and cylindrical velum in well-preserved specimens.

Remarks.—*Rolumbus mirus,* n. sp., differs from *R. hamiltoni,* n. sp., by having slender horns and feet, by having more fragile (less massive) pore frames, and by having a more cylindrical velum.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	24 (10)	37 (10)	13 (10)
length of thorax	75	75 (10)	100 (10)	38 (10)
width of thorax at top	50	45 (10)	50 (10)	25 (10)
width of thorax at base	100	103 (10)	125 (10)	55 (10)
length of foot (maximum)	170	134 (8)	170 (8)	63 (8)
length of apical horn	88	70 (9)	88 (9)	50 (9)
length of vertical horn	100	89 (8)	100 (8)	75 (8)
distance between horn tips	175	161 (7)	175 (7)	138 (7)

Type locality.—OR-600 (see *Appendix*).

Deposition of types.—Holotype: USNM 379284; paratypes: USNM 379285 and Pessagno Collection.

Range.—Lower Jurassic: lower Toarcian (Text-fig. 7).

Occurrence.—The Hyde Formation, east-central Oregon. Tethyan Realm (Text-fig. 5).

Rolumbus venustus, new species
Plate 5, figures 2, 3, 18

Etymology.—(L.) *venustus* = graceful.

Diagnosis.—Cephalis imperforate, hemispherical, with two straight horns; horns triradiate, moderate in length, vertical horn commonly slightly shorter than apical horn. Thorax trapezoidal in side view, comprised of variably-sized polygonal pore frames with narrow rims and sides. Four feet moderate in length, straight, triradiate with three narrow ridges alternating with three wide grooves, one ridge of each foot extending upward to top of thorax.

Remarks.—*Rolumbus venustus,* n. sp., differs from *R. mirus,* n. sp., by having thorax with trapezoidal outline in side view.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	26.2 (6)	32.5 (6)	25 (6)
length of thorax	100	72.9 (6)	100 (6)	62.5 (6)
width of thorax at top	50	49.6 (6)	50 (6)	47.5 (6)
width of thorax at base	125	107.5 (6)	125 (6)	92.5 (6)
length of foot (maximum)	115	118 (5)	125 (5)	100 (5)
length of apical horn	62.5	70 (5)	82.5 (5)	52.5 (5)
length of vertical horn	75	72.5 (6)	75 (6)	52.5 (6)
distance between horn tips	125	125.5 (5)	150 (5)	102 (5)

Type locality.—OR-600 (see *Appendix*).

Deposition of types.— Holotype: USNM 379286; paratypes: USNM 379287 and Pessagno Collection.

Range.—Lower Jurassic: upper Pliensbachian to middle Toarcian (Text-fig. 7).

Occurrence.—The Nicely Formation, the Hyde Formation, and the Warm Springs Member of the Snowshoe Formation, east-central Oregon. Tethyan Realm (Text-fig. 5).

Family **HILARISIREGIDAE**
Takemura and Nakaseko, 1982
(corrected name)

Type genus.—*Hilarisirex* Takemura and Nakaseko, 1982 (emended herein).

Emended definition.—Test tricyrtid with four feet and one or two massive horns (Pl. 1, fig. 4; Pl. 8, figs. 12, 18, 19). Feet and horns triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves. Cephalis with primary left lateral, primary right lateral, vertical, median, secondary left lateral, secondary right lateral, and apical bars; dorsal bar absent in cyrtoid configuration of cephalic skeletal elements. Cephalic and thoracic walls possessing an inner latticed layer of polygonal pore frames and an outer layer of microgranular silica. Thorax small, trapezoidal in outline, separated from abdomen by an internal partition which is welded to top of A-frame (see below and Pl. 1, fig. 17). Abdominal wall either single-layered (*Diceratigalea* Takemura and Nakaseko, 1982) or double-layered (*Hilarisirex* Takemura and Nakaseko, 1982); when single-layered consisting of massive polygonal pore frames of high relief; when double-layered consisting of an inner layer of smooth, flattened pore frames overlain by a layer consisting of

irregularly-arranged, interconnected bars forming a vermicular pattern and irregularly-shaped pore frames (Pl. 8, figs. 13, 14, 17–19). Abdomen four-sided. Each side comprised of an A-frame component formed by feet and their proximal extensions. Feet and their proximal extensions welded internally to corners of imperforate square partitions that occur at the base of the thorax and abdomen. Internal partition at base of abdomen giving rise internally to latticed partition with circular aperture (mouth); aperture bordered by raised, imperforate rim (Pl. 1, figs. 6, 17). Four feet opposed to two secondary and two primary lateral bars.

Remarks.—The Hilarisiregidae differ from the Ultranaporidae Pessagno (1977b) by possessing a tricyrtid test with four feet, by lacking a dorsal bar (Pl. 1, fig. 17) among the cephalic skeletal elements, and by possessing A-frames (Pl. 1, figs. 4, 17; Pl. 8, figs. 17–19).

Early Jurassic forms included in this report in the Farcidae, n. fam., are most likely ancestral to the Hilarisiregidae (see Farcidae, herein). The Hilarisiregidae are compared to the Farcidae under the latter family.

Takemura and Nakaseko (1982, pp. 442–464) included the Hilarisireginae (= their Hilarisirecinae) in the Palaeoscenidiidae Riedel, 1967. Their definition (p. 457) of the Hilarisireginae is as follows: "Palaeoscenidiidae with two apical spines and four basal spines, possessing poreless and spherical cephalis in the apical hemisphere and thorax in the basal hemisphere. Median bar, two apical spines composing cephalic skeletal elements." Takemura and Nakaseko (1982, p. 458) noted that the cephalis of members of this subfamily includes seven cephalic skeletal elements that may correspond to those of the Nassellariina: a median bar, an apical bar, a vertical bar, two lateral bars (= primary lateral bars *sensu* Goll, 1968, p. 1413; Pessagno, 1969, p. 423), and two secondary lateral bars. They also noted correctly that a dorsal bar is absent.

We feel that the definition presented by Takemura and Nakaseko (1982) is inaccurate. To begin with, the Hilarisiregidae are virtually unrelated to the Palaeoscenidiidae Riedel, 1967. The four basal spines are in fact four feet that are not connected to the cephalic skeletal elements; the feet and their proximal extensions form the sides of the abdominal A-frames described above. As noted by Dumitrica (1978, p. 40) the four divergent basal spines of *Palaeoscenidium* Deflandre, 1953, emerge apically from the center of a very short bar. The test of *Hilarisirex* Takemura and Nakaseko, 1982, is clearly tricyrtid and not dicyrtid as claimed by Takemura and Nakaseko; it includes a well-defined cephalis, a well-defined thorax, and a well-defined abdomen (Pl. 1, fig. 17). The cephalis and thorax (= *cephalis* of Takemura and Nakaseko, 1982) consists of a latticed, perforate inner layer, which on well-preserved specimens is covered by an outer layer of microgranular silica. It is likely that the microgranular outer layer was formed at a late stage in ontogeny; immature specimens probably possess a perforate, latticed cephalis and thorax. On some specimens the rims of polygonal pore frames can be seen projecting through the thin veneer of microgranular silica (Pl. 8, figs. 6, 14). The abdominal wall of the type genus *Hilarisirex* possesses two latticed layers whereas that of *Diceratigalea* Takemura and Nakaseko, 1982, possesses a single latticed layer.

Range.—Middle Jurassic (Aalenian?); lower Bajocian to Upper Jurassic (upper Kimmeridgian/lower Tithonian).

Occurrence.—Snowshoe Formation of east-central Oregon; Eugenia Formation of Baja California Sur; volcanogenic–pelagic strata above the Coast Range ophiolite, California Coast Ranges; Mino Belt of central Japan. Tethyan Realm to Boreal Realm.

Genus **HILARISIREX**
Takemura and Nakaseko, 1982

Type species.—*Hilarisirex quadrangularis* Takemura and Nakaseko, 1982.

Emended definition.—Test as with family but possessing a vertical horn and an apical horn connected to vertical and apical bars respectively. Abdomen with an inner latticed layer of flattened, smooth polygonal pore frames and an outer latticed layer consisting of irregular, interconnecting bars that form a vermicular pattern, and irregular polygonal pore frames.

Remarks.—*Hilarisirex* Takemura and Nakaseko, 1982, differs from *Diceratigalea* Takemura and Nakaseko, 1982, by having an abdominal wall with two latticed layers instead of a single one, and by having more strongly-developed A-frames.

Range.—Lower Jurassic (middle Toarcian) to Upper Jurassic (upper Kimmeridgian/lower Tithonian).

Occurrence.—Snowshoe Formation of east-central Oregon; Eugenia Formation, Baja California Sur; volcanogenic–pelagic strata overlying Coast Range ophiolite at Point Sal, Santa Barbara County, California; and Mino Belt of Central Japan. Tethyan Realm to Boreal Realm.

Hilarisirex inflatus, new species
Plate 1, figure 17; Plate 8, figures 4–6, 10, 13, 14, 17; Plate 11, figure 1

Etymology.—(L.) *inflatus* = inflated, swollen.

Diagnosis.—Apical and vertical horns triradiate in axial section, nearly equal in length with three ridges of medium width alternating with three grooves of medium width; grooves and ridges gradually narrow-

ing distally and extending to tips of horns. Four feet widely separated, triradiate in axial section, about two times as long as horns; three medium-width ridges alternating with three medium-width grooves: both ridges and grooves gradually decrease in width distally. Abdomen with four inflated, convexly-arched walls linked to A-frames. Inner latticed layer of abdomen consisting of irregular, fairly uniformly-sized, tetragonal and pentagonal pore frames. Outer latticed layer weakly- to well-developed with irregular vermicular ridges.

Remarks.—*Hilarisirex inflatus,* n. sp., is compared to *H. oregonensis,* n. sp., under the latter species. It differs from *H. quadrangularis* Takemura and Nakaseko, 1982 (p. 458) by having inflated abdominal walls, more widely-separated feet, and a shorter abdomen.

Measurements (in μm).—Numbers of specimens measured are in parentheses, X = broken.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis and thorax	36.3	27.2 (9)	40 (9)	25 (9)
length of abdomen	72.6	77.3 (9)	100 (9)	65 (9)
width of A-frame at top	42.9	51.6 (9)	60 (9)	40 (9)
width of A-frame at base	125.4	124.3 (9)	180 (9)	100 (9)
length of foot (maximum)	X	127.5 (7)	165 (7)	85 (7)
length of apical horn	89	85.4 (9)	112 (9)	60 (9)
length of vertical horn	89	83 (7)	112 (7)	72.8 (7)
distance between horn tips	122	162.4 (7)	240 (7)	120 (7)

Type locality.—OR-501B (see *Appendix*).

Deposition of types.—Holotype: USNM 379288; paratypes: USNM 379289 and Pessagno Collection.

Range.—Middle Jurassic (upper Bathonian) so far as known (Text-fig. 7).

Occurrence.—South Fork Member of the Snowshoe Formation, east-central Oregon. Boreal Realm (Text-fig. 6).

Hilarisirex oregonensis, new species
Plate 7, figures 17, 18; Plate 8, figures 12, 18, 19

Etymology.—Named for the state of Oregon.

Diagnosis.—Vertical and apical horns triradiate in axial section; vertical horn commonly shorter than apical horn; both horns with three moderately-wide grooves alternating with three moderately-wide ridges; grooves gradually wedging out distally; ridges maintaining the same width and extending to tips of horns. Feet triradiate, about two times length of horns and displaying alternating ridges and grooves of moderate width. Abdomen elongate, having four planiform walls that are linked to A-frames. Inner latticed layer of abdomen consisting of fairly uniformly-sized triangular, tetragonal, and pentagonal pore frames; outer latticed layer consisting of irregular vermicular ridges that interconnect to form irregular pore frames.

Remarks.—*Hilarisirex oregonensis,* n. sp., differs from *H. inflatus,* n. sp., by having an abdomen with four planiform sides, by having a more elongate abdomen, and by usually having a shorter vertical horn.

Measurements (in μm).—Numbers of specimens measured are in parentheses, X = broken.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis and thorax	45	49 (7)	72 (7)	35.2 (7)
length of abdomen	100	88.9 (7)	136 (7)	66 (7)
width of A-frame at top	62.5	57.9 (7)	72 (7)	48.4 (7)
width of A-frame at base	120	124.5 (7)	172 (7)	95.2 (7)
length of foot (maximum)	X	—	200 (2)	118.8 (2)
length of apical horn	87.5	80.9 (6)	96 (6)	58.8 (6)
length of vertical horn	75	74.7 (5)	96 (5)	58.8 (5)
distance between horn tips	175	161.8 (5)	184.8 (5)	117.6 (5)

Type locality.—OR-501B (see *Appendix*).

Deposition of types.—Holotype: USNM 379290; paratypes: USNM 379291 and Pessagno Collection.

Range.—Middle Jurassic (upper Bathonian) so far as known (Text-fig. 7).

Occurrence.—Snowshoe Formation of east-central Oregon. Boreal Realm (Text-fig. 6).

Hilarisirex species A
Plate 7, figures 1, 20

Range and occurrence.—Middle Jurassic (lower Bajocian) (loc. OR-594). Warm Springs Member of the Snowshoe Formation of east-central Oregon (see *Appendix*). Rare. Tethyan Realm.

Hilarisirex species B
Plate 7, figure 16

Range and occurrence.—Middle Jurassic (lower Bajocian) (loc. OR-554). Warm Springs Member of the Snowshoe Formation of east-central Oregon (see *Appendix*). Rare. Tethyan Realm.

Hilarisirex species C
Plate 7, figure 15

Range and occurrence.—Middle Jurassic (upper part of lower Bajocian) (loc. OR-549B). Snowshoe Formation (undifferentiated) (see *Appendix*). Rare. Tethyan Realm.

Hilarisirex species D
Plate 10, figure 1

Range and occurrence.—Upper Jurassic (upper Kimmeridgian: upper part of Zone 2 of Pessagno, Blome, and Longoria (1984)) (loc. NSF-907; see *Appendix*). Volcanogenic-pelagic strata overlying Coast Range ophiolite at Point Sal, Santa Barbara County, California. Rare. Boreal Realm, Southern Boreal Province.

Family **ULTRANAPORIDAE** Pessagno, 1977b

Type genus.—*Ultranapora* Pessagno, 1977b (= *Napora* Pessagno, 1977a).

Emended diagnosis.—Dicyrtid cyrtoid Nassellariina with both cephalis and thorax comprised of a single latticed layer. Cephalis hemispherical, covered by layer of microgranular silica on well-preserved specimens; cephalis with prominent horn that may be entirely triradiate or partially triradiate in axial section; horn with or without subsidiary spines. Cephalis with cyrtoid cephalic skeletal elements including primary left lateral bar, primary right lateral bar, vertical bar, median bar, apical bar, secondary right lateral bar, secondary left lateral bar, and dorsal bar (Pl. 1, figs. 8, 15). Apical bar connected to horn; vertical bar connected to cephalocone or spinelike cephalocone (e.g., *Jacus* De Wever, 1982); cephalocone or spinelike cephalocone surrounded by circular opening in some genera (e.g., *Jacus*). Thorax large, hemispherical, with three prominent feet that are triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves. Aperture (mouth) at base of thorax with or without a thoracic velum; aperture circular to subcircular to subtriangular in outline, bordered by a raised imperforate rim.

Remarks.—*Napora* differs from *Jacus* by lacking a thoracic velum and possessing more regular thoracic pore frames. In this report we tentatively include *Jacus* in the Ultranaporidae and suggest that it gave rise to *Napora* through the loss of the velum and the acquisition of more regular thoracic pore frames that are not separated by ridges. Note the unnamed dicyrtid nassellarian (ultranaporid?) (Pl. 1, fig. 7) with two feet may be a member of this family.

Range.—Lower Jurassic: upper Sinemurian (?); lower Pliensbachian to Upper Cretaceous.

Occurrence.—World-wide in Tethyan and Boreal Realms.

Genus **JACUS** De Wever, 1982

Type species.—*Jacus coronatus* De Wever, 1982.

Remarks.—*Jacus* differs from *Napora* Pessagno, 1977a, 1977b, by possessing a thoracic velum. According to De Wever (1982, pp. 204–205), *Jacus* differs from *Napora* by lacking a cephalocone. In its place there is a circular opening with a spine protruding from its center. The spine is apparently an extension of the vertical bar (cephalic skeletal element). Although De Wever infers that this spine is solid, his illustrations (pl. 12, fig. 5 = holotype) of *Jacus coronatus,* the type species of *Jacus,* clearly indicate that the spine is in fact porous. Pessagno (1977b, pl. 5, figs. 14, 21) illustrated two types of cephalocones. One type (fig. 14) is conical and perforated by a number of slitlike pores; the other type (fig. 21) is spinelike and possesses three(?) pores. We suggest that the perforate spine figured by De Wever is representative of this latter type of cephalocone. Whether one calls this structure a spine or cephalocone is perhaps immaterial since it protrudes from a circular opening in the cephalic wall. No specimens of *Napora* have spines protruding from such an opening.

Range.—Lower Jurassic: lower Pliensbachian (?); upper Pliensbachian; Toarcian (?).

Occurrence.—Lower Jurassic: lower Pliensbachian to middle Toarcian. Tethyan Realm; ?Boreal Realm.

Jacus reiferensis, new species
Plate 4, figures 7, 8, 11; Plate 5, figures 6, 14

Etymology.—This species is named for Pico Reifer, which is located east of its type area.

Diagnosis.—Cephalis medium-sized, hemispherical, commonly covered with a thin layer of microgranular silica; small spine may extend from base of cephalis. Apical horn massive, more than one-half length of test, distally trifurcating. Proximal two-thirds of horn triradiate in axial section with narrow, rounded ridges and broad grooves; distal portion of horn separated into three tapering lobes; lobes elliptical in cross-section, approximately at right angles to long axis of test and in some specimens curving slightly downward; lobes of horn ranging from one-half to equal the length of the triradiate portion of horn. Thorax subpyramidal in outline with small- to medium-sized, slightly no-

dose, irregularly-shaped, elliptical and tetragonal pore frames; pore frames arranged in poorly-defined transverse rows separated by transverse ridges. Massive triradiate feet, attached to base of thorax, curved slightly inward. Subsidiary meshwork (velum?), with very irregularly-shaped and -spaced pore frames and imperforate rim, some attached to base of thorax. Mouth subtriangular in outline.

Remarks.—*Jacus reiferensis,* n. sp., is distinguished from *Jacus coronatus* De Wever, 1982, by the nature of the meshwork on the thorax and velum(?) as well as the structure of the horn.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	20	20.9 (11)	25 (11)	15 (11)
length of thorax	50	63.1 (11)	80 (11)	50 (11)
width of thorax at top	45	43.1 (11)	50 (11)	40 (11)
width of thorax at base	110	100 (11)	120 (11)	90 (11)
length of horn	65	63.6 (11)	85 (11)	55 (11)
width of horn at base	25	20.4 (11)	25 (11)	15 (11)
length of foot (maximum)	100	93.5 (10)	120 (10)	70 (10)

Type locality.—BPW-30 (see *Appendix*).

Deposition of types.—Holotype: USNM 379292; paratypes: USNM 379293 and Pessagno Collection.

Range.—Lower Jurassic: upper Pliensbachian so far as known (Text-fig. 7).

Occurrence.—San Hipólito Formation, sandstone member, Baja California Sur. ? Boreal Realm (Text-fig. 5).

Jacus (?) **sandspitensis**, new species
Plate 2, figures 5, 9, 13, 16, 17; Plate 11, figure 13

Etymology.—This species is named for the town of Sandspit in the Queen Charlotte Islands, British Columbia.

Diagnosis.—Cephalis small, hemispherical, with small cephalocone and relatively short horn. Proximal two-thirds of horn triradiate in axial section with three narrow grooves alternating with three rounded ridges of approximately the same width. Grooves often deeply-incised proximally, becoming shallower distally; ridges each bearing short spines before their termination. Distal one-third of horn circular in axial section; lacking ridges and grooves. Thorax with very coarse, nodose polygonal pore frames; distal portion of thorax with mixture of tetragonal and pentagonal pore frames arranged in rows between angled ridges. Feet long, triradiate in axial section with three narrow ridges that alternate with three wide grooves; short spines occur along ridges on proximal half of each foot, suggesting velum attachment. Mouth subcircular in outline, surrounded by an imperforate rim.

Remarks.—This species is questionably assigned to *Jacus* because it possesses a true cephalocone. It is conceivable that the spine extending from the "hole" (cephalopyle?) of De Wever's (1982) specimens of *Jacus* merely represents a remnant of a fragile cephalocone not preserved in his badly-etched material. The presence of a velum in *J.* (?) *sandspitensis* is probably indicated by the short spines that occur on the proximal half of the feet. It should be noted that some specimens of *Napora,* such as *N. praespinifera* (Pessagno, 1977b) and *N. spinifera* (Pessagno, 1977b) display velum-like structure below the thorax and between the proximal halves of the feet; however, we have never observed the basal closure of this velum-like structure. *Jacus* (?) *sandspitensis* differs from *J. coronatus* De Wever, 1982, by possessing a structurally simpler horn lacking a crownlike mass at its tip, and by having considerably longer, slender feet. Both species possess ridges at the base of the thorax, which separate rows of pore frames.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	23.8 (9)	25 (9)	15 (9)
length of thorax	100	76.1 (9)	100 (9)	55 (9)
width of thorax at top	50	48.0 (9)	62.5 (9)	40 (9)
width of thorax at base	112.5	105.5 (9)	125 (9)	95 (9)
length of horn	55	81.7 (7)	92.5 (7)	50 (7)
width of horn at base	47.5	35.8 (9)	47.5 (9)	25 (9)
length of foot (maximum)	170	147.5 (5)	175 (5)	95 (5)

Type locality.—QC-534 (see *Appendix*).

Deposition of types.—Holotype: USNM 379294; paratypes: USNM 379295 and Pessagno Collection.

Range.—Lower Jurassic: lower Pliensbachian so far as known (Text-fig. 7).

Occurrence.—Lower Pliensbachian portion of the Maude Formation. Tethyan Realm (Text-fig. 5).

Jacus (?) species aff. **J.** (?) **sandspitensis**, new species
Plate 3, figure 2

Remarks.—This form differs from *J.* (?) *sandspitensis,* n. sp., by having a much longer horn.

Range and occurrence.— Lower Jurassic (upper lower Pliensbachian to lower upper Pliensbachian) cherts

from the Franciscan Complex of California (loc. NSF-960). Tethyan Realm.

Jacus (?) species A
Plate 5, figure 4

Remarks.—This form is quite similar to *Jacus* (?) sp. aff. *J.* (?) *sandspitensis,* n. sp. It differs by having a horn with narrower ridges.

Range and occurrence.—Lower Jurassic: upper Pliensbachian; ? lower Toarcian. Maude Formation, Queen Charlotte Islands, British Columbia (loc. QC-622). Tethyan Realm.

Jacus (?) species B
Plate 5, figure 9

Remarks.—This form is questionably assigned to *Jacus* De Wever by having a spinelike cephalocone and by having ridgelike structures at the basal part of thorax that are similar to those of *Jacus.*

Range.—Lower Jurassic: upper Pliensbachian to lower Toarcian (Text-fig. 7).

Occurrence.—Nicely Formation (loc. OR-536) and the Hyde Formation (loc. OR-600), east-central Oregon. Tethyan Realm (Text-fig. 5).

Jacus (?) species C
Plate 3, figure 20

Remarks.—The absence of tapering lobes on the massive horn of *Jacus* (?) sp. C distinguishes it from *Jacus reiferensis,* n. sp.

Range.—Lower Jurassic: upper Pliensbachian so far as known.

Occurrence.—San Hipólito Formation, sandstone member, Baja California Sur (loc. SH-412-14). ? Boreal Realm.

Genus **NAPORA** Pessagno, 1977a

Napora Pessagno, 1977a, p. 94.
Ultranapora Pessagno, 1977b, p. 38.

Type species.—*Napora bukryi* Pessagno, 1977a.

Emended diagnosis.—As with that of family but restricted to forms that lack a thoracic velum and may or may not have a cephalocone.

Remarks.—Pessagno (1977a, 1977b) considered *Napora* to differ from *Ultranapora* by lacking a cephalocone. Because we have observed a cephalocone on specimens of *Napora bukryi* Pessagno, 1977a, the type species of *Napora,* this definition is no longer valid. *Ultranapora* must therefore be considered a junior synonym of *Napora.* Although forms that appear to lack a cephalocone may be present in our Jurassic samples, we tentatively include all such forms under *Napora* until the taxonomic and phylogenetic significance of the cephalocone is assessed. This more conservative approach corresponds to that of Baumgartner, De Wever, and Kocher (1980).

It should be noted that ultranaporids possessing a large cephalis commonly have a large cephalocone (Pl. 6, figs. 2, 16, 20; Pl. 7, figs. 10–12, 14). Generally, such forms likewise possess horns that are offset from the longitudinal axis of test growth, in a direction away from the cephalocone. Conversely, forms with a small cephalis possess a small cephalocone and a more centrally-placed horn. The cephalocone of *N. bukryi,* for example, is minute and easily overlooked.

Range.—Lower Jurassic (upper Sinemurian (?); lower Pliensbachian) to Upper Cretaceous.

Occurrence.—World-wide in Tethyan and Boreal Realms.

Napora antelopensis, new species
Plate 8, figures 2, 3, 15, 20–23; Plate 11, figure 18

Etymology.—This species is named for Antelope Creek, which is located near its type locality.

Diagnosis.—Cephalis small, hemispherical with relatively short horn. Horn triradiate in axial section with three narrow ridges alternating with three narrow grooves. Three nodelike spines appearing on ridges in middle of horn; proximal one-half of each ridge about two times the width of distal half; short subsidiary grooves commonly developed on ridges on proximal one-half of horn. Thorax with mixture of variably-sized tetragonal (rare), pentagonal, and hexagonal pore frames with narrow rims and deep sides. Feet short, triradiate in axial section, somewhat incurved with three narrow grooves alternating with three narrow ridges. Aperture (mouth) subcircular in outline with imperforate rim.

Remarks.—*Napora antelopensis,* n. sp., differs from *N. lospensis* Pessagno, 1977a, by having a longer, structurally different horn, larger and more delicate thoracic pore frames, and longer feet.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	20	24 (10)	30 (10)	20 (10)
length of thorax	100	82.5 (10)	100 (10)	60 (10)
width of thorax at top	50	65 (10)	75 (10)	50 (10)
width of thorax at base	125	122.2 (10)	137.5 (10)	100 (10)
length of horn	75	69 (10)	80 (10)	55 (10)
width of horn at base	25	25 (10)	30 (10)	20 (10)
length of foot (maximum)	175	112.8 (7)	175 (7)	75 (7)

Type locality.—OR-501B (see *Appendix*).

Deposition of types.—Holotype: USNM 379296; paratypes: USNM 379297 and Pessagno Collection.

Range and occurrence.—Middle Jurassic (upper Bathonian); South Fork Member of the Snowshoe Formation, east-central Oregon. Boreal Realm (Text-figs. 6, 7).

Napora baumgartneri, new species
Plate 6, figures 11, 13, 15, 19, 22–24

Etymology.—This species is named for Dr. Peter O. Baumgartner (Université de Lausanne, Switzerland), in honor of his contributions to the study of Jurassic Radiolaria.

Diagnosis.—Cephalis small, hemispherical, with short horn. Horn triradiate in axial section with three medium-width grooves alternating with three rounded ridges; ridges of medium width on proximal two-thirds of horn, decreasing slightly in width distally and giving rise to weakly-developed nodelike spines on each ridge. Distal one-third of horn with shallow grooves and weakly-developed ridges. Thorax inflated, hemispherical with tetragonal, pentagonal, and hexagonal pore frames; pore frames somewhat nodose, varying in size, but predominantly medium-sized with wide rims. Feet triradiate in axial section, incurved with three shallow, narrow grooves alternating with three narrow ridges; ridges very high in relief, particularly on distal half of a given foot.

Remarks.—*Napora baumgartneri,* n. sp., differs from *N. cosmica,* n. sp., by having a simpler, more massive horn, by having feet that are shorter and not as curved, and by having a more inflated thorax with larger pore frames. In addition the ridges on the feet of *N. baumgartneri* are higher in relief distally whereas those of *N. cosmica* are higher in relief proximally.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	24 (10)	25 (10)	20 (10)
length of thorax	75	76.2 (10)	100 (10)	50 (10)
width of thorax at top	75	65 (10)	75 (10)	50 (10)
width of thorax at base	100	107 (10)	125 (10)	87.5 (10)
length of horn	37.5	54.2 (10)	70 (10)	37.5 (10)
width of horn at base	25	23.7 (10)	25 (10)	20 (10)
length of foot (maximum)	120	103.1 (10)	125 (10)	82.5 (10)

Type locality.—OR-554 (see *Appendix*).

Deposition of types.—Holotype: USNM 379298; paratypes: USNM 379299 and Pessagno Collection.

Range.—Middle Jurassic: lower Bajocian (Text-fig. 7).

Occurrence.—Warm Springs Member of the Snowshoe Formation, east-central Oregon. Tethyan Realm (Text-fig. 6).

Napora bearensis, new species
Plate 7, figures 10–12; Plate 11, figure 7

Etymology.—This species is named for Bear Valley, which is located near its type locality.

Description.—Cephalis large, hemispherical, with large cephalocone and horn of medium length. Horn triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves. Proximal two-thirds of horn two or three times the width of distal one-third and possessing medium-width parallel ridges alternating with somewhat wider grooves; ridges each giving rise to short spines at point where horn suddenly decreases in width. Distal one-third of horn with narrower ridges alternating with narrow, shallow, poorly-defined grooves. Thorax subpyramidal with variably-sized, predominantly large, slightly nodose pentagonal and hexagonal pore frames. Pore frames adjacent to feet and mouth commonly arranged in poorly-defined rows. Feet triradiate in axial section with three narrow, sharply-bladed ridges alternating with three wide U-shaped grooves. Feet proximally flaring slightly outwards; distally becoming slightly incurved.

Remarks.—*Napora bearensis,* n. sp., differs from *N. browni,* n. sp., by possessing more symmetrical, constant-sized pore frames and by having a straight, more symmetrical horn.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	25.2 (9)	27 (9)	25 (9)
length of thorax	75	59.1 (9)	75 (9)	50 (9)
width of thorax at top	50	48.6 (9)	50 (9)	37.5 (9)
width of thorax at base	100	100.5 (9)	112.5 (9)	75 (9)
length of horn	52.5	49.6 (8)	62.5 (8)	37.5 (8)
width of horn at base	20	21.5 (9)	22.5 (9)	17.5 (9)
length of foot (maximum)	87.5	71.6 (7)	100 (7)	50 (7)

Type locality.—OR-549B (see *Appendix*).

Deposition of types.—Holotype: USNM 379300; paratypes: USNM 379301 and Pessagno Collection.

Range.—Middle Jurassic: upper lower Bajocian (Text-fig. 7).

Occurrence.—Snowshoe Formation (undifferentiated), east-central Oregon. Tethyan Realm (Text-fig. 6).

Napora bona, new species
Plate 6, figures 4, 5

Etymology.—(L.) *bonus* = good, useful.

Diagnosis.—Cephalis large, hemispherical, with well-developed large cephalocone and a medium-length horn. Horn triradiate in axial section with three medium-width longitudinal ridges alternating with three somewhat wider longitudinal grooves; ridges wider on proximal two-thirds of horn, flaring outwards to give rise to three short spines. Thorax pyramidal with linear, circumferentially-arranged tetragonal pore frames; faces of distal one or two rows of pore frames sloping inwards. Feet incurved, triradiate in axial section with three sharply-bladed longitudinal ridges alternating with three wide longitudinal grooves; ridges high in relief.

Remarks.—*Napora bona* appears closely related to *Napora* sp. A (Pl. 7, fig. 14). It differs from the latter form by possessing larger, less numerous, and more irregularly-shaped thoracic pore frames. Both forms display a row of inwardly-sloping pore frames at the base of the thorax. *N. bona* differs from *N. cosmica,* n. sp., by having a larger cephalis with a well-developed cephalocone; shorter, less curved feet; larger, less numerous, more irregular thoracic pore frames; a shorter, more massive horn; and an inturned row of pore frames at the base of the thorax.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	20	22.5 (7)	25 (7)	12.5 (7)
length of thorax	37.5	32.8 (7)	37.5 (7)	25 (7)
width of thorax at top	37.5	36.4 (7)	37.5 (7)	30 (7)
width of thorax at base	70	77.1 (7)	95 (7)	62.5 (7)
length of horn	32.5	45.6 (4)	50 (4)	32.5 (4)
width of horn at base	20	21.4 (7)	25 (7)	17.5 (7)
length of foot (maximum)	62.5	67.5 (4)	82.5 (4)	50 (4)

Type locality.—OR-580 (see *Appendix*).

Deposition of types.—Holotype: USNM 379302; paratypes: USNM 379303 and Pessagno Collection.

Range.—Middle Jurassic: Aalenian to lower Bajocian (Text-fig. 7).

Occurrence.—Warm Springs Member of the Snowshoe Formation of east-central Oregon. Tethyan Realm (Text-fig. 6).

Napora boneti, new species
Plate 9, figures 3, 4, 17, 19, 23

Etymology.—This species is named for the late Dr. Federico Bonet (Institute of Petroleum, Mexico, D.F., Mexico), in honor of his many valuable contributions to Mexican micropaleontology and biostratigraphy.

Diagnosis.—Cephalis small, hemispherical, with cephalocone and medium-length horn. Proximal one-half of horn triradiate in axial section with three deep, narrow longitudinal grooves alternating with three parallel, massive, rounded ridges. Distal half of horn circular in axial section, lacking longitudinal ridges and grooves; about one-half the width of proximal half. Thorax hemispherical with massive, nodose, relatively large pentagonal and hexagonal pore frames. Feet of medium length, triradiate in axial section with three rounded longitudinal ridges that alternate with three deep longitudinal grooves; ridges and grooves about equal in width.

Remarks.—*Napora boneti,* n. sp., differs from *N. burckhardti,* n. sp., by having shorter feet and a proportionately smaller thorax with larger, more massive, and less numerous nodose pore frames. Furthermore, the thorax of *N. boneti* is hemispherical in shape, whereas that of *N. burckhardti* is subcylindrical. The two species share horns of similar structure and it is likely that *N. boneti,* n. sp., is ancestral to *N. burckhardti,* n. sp.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	23.2 (9)	25 (9)	17.5 (9)
length of thorax	75	66.6 (9)	75 (9)	50 (9)
width of thorax at top	50	53.6 (9)	62.5 (9)	37.5 (9)
width of thorax at base	87.5	87.5 (9)	110 (9)	62.5 (9)
length of horn	80	63.4 (8)	80 (8)	32.5 (8)
width of horn at base	25	24.4 (9)	37.5 (9)	22.5 (9)
length of foot (maximum)	75	67.4 (4)	75 (4)	50 (4)

Type locality.—MX-82-15 (see *Appendix*).

Deposition of types.—Holotype: USNM 379304; paratypes: USNM 379305 and Pessagno Collection.

Range.—Upper Jurassic: upper Kimmeridgian, upper Zone 2 (Text-fig. 7).

Occurrence.—Taman Formation of east-central Mexico. Tethyan Realm (Text-fig. 6).

Napora browni, new species
Plate 6, figures 6, 7

Etymology.—This species is named for C. E. Brown (U. S. Geological Survey), in honor of his contributions to the geology of the John Day Inlier, east-central Oregon.

Diagnosis.—Cephalis large, hemispherical, with cephalocone and wide, massive horn of medium length. Horn triradiate in axial section with three wide grooves alternating with three rounded, wide ridges. Horn asymmetrical; distal half to one-third offset from long axis of test at an angle. Grooves lenticular in outline, wide medially. Proximal half of ridges straight, developing shallow subsidiary grooves that deepen towards cephalis; distal half of ridges commonly lower in relief, separated from proximal portions by sharp line of demarcation (break in slope). Thorax hemispherical with irregularly-sized and -shaped, relatively massive tetragonal, pentagonal, and hexagonal pore frames (pentagonal and hexagonal pore frames predominating). Feet short, slightly incurved, triradiate in axial section with three narrow ridges alternating with three wide grooves.

Remarks.—*Napora browni,* n. sp., differs from all other species of *Napora* by virtue of the asymmetrical, crooked nature of its horn.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	20	23.7 (8)	25 (8)	20 (8)
length of thorax	50	48.7 (8)	62.5 (8)	37.5 (8)
width of thorax at top	50	47.5 (8)	55 (8)	37.5 (8)
width of thorax at base	87.5	94.6 (8)	100 (8)	87.5 (8)
length of horn	70	66.2 (6)	75 (6)	55 (6)
width of horn at base	12.5	23.7 (8)	40 (8)	12.5 (8)
length of foot (maximum)	75	—	75 (2)	75 (2)

Type locality.—OR-580 (see *Appendix*).

Deposition of types.—Holotype: USNM 379306; paratypes: USNM 379307 and Pessagno Collection.

Range.—Middle Jurassic: Aalenian (?) so far as known (Text-fig. 7).

Occurrence.—Warm Springs Member of the Snowshoe Formation, east-central Oregon. Tethyan Realm (Text-fig. 6).

Napora bukryi Pessagno
Plate 9, figures 5, 12–14

Napora bukryi Pessagno, 1977a, pp. 94–96, pl. 12, fig. 8.
Napora lospensis Pessagno, 1977a. Baumgartner, De Wever, and Kocher, 1980, p. 57, pl. 3, fig. 4.

Remarks.—The holotype (Pl. 9, fig. 5) of *Napora bukryi* appears to have a small hemispherical thorax but actually the thorax is relatively large. The apparent small size of the thorax of the holotype was a consequence of the foreshortening resulting from the tilted view of the specimen. A minute cephalocone has been observed on topotypes and on specimens from locality NSF-908 (Pl. 9, fig. 12).

Deposition of types.—Holotype: USNM 22002.

Range.—Zone 2 (upper) to Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984). Upper Jurassic: upper Kimmeridgian to lower Tithonian.

Occurrence.—Volcanogenic-pelagic strata above the Coast Range ophiolite at Point Sal, Santa Barbara County, California. Upper Jurassic of Greece. Boreal and Tethyan Realms.

Napora burckhardti, new species
Plate 10, figures 2–5, 15, 16, 21–23

Etymology.—This species is named for Carlos Burckhardt, in honor of his pioneering studies of the Jurassic stratigraphy and ammonite faunas of Mexico during the early 1900's.

Diagnosis.—Cephalis relatively large, hemispherical, with medium-length horn. Proximal half of horn triradiate in axial section with three wide, rounded ridges alternating with three narrow, deep grooves; distal one-half of horn circular in axial section, rapidly tapering to pointed tip. Medial portion of horn swollen due to thickening of ridges. Cephalis and proximal half of horn frequently covered with layer of microgranular silica that may obscure triradiate structure. Thorax subcylindrical in shape with medium-sized, slightly nodose tetragonal and pentagonal pore frames; pore frames arranged in poorly-defined transverse rows. Feet of moderate length, curved inwards towards long axis of test; with three wide grooves alternating with three narrow, rounded ridges. Mouth circular in outline, bounded by imperforate rim.

Remarks.—*Napora burckhardti,* n. sp., differs from *Napora lospensis* Pessagno, 1977a, by having a subcylindrical thorax with wider, less massive pore frames, a considerably longer, less massive horn, which is circular in axial section distally, and much longer, more curved feet. *N. burckhardti* differs from *N. bukryi* Pessagno, 1977a, by having a subcylindrical thorax, a longer horn with different structure, and longer feet.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	25.5 (10)	30 (10)	25 (10)
length of thorax	75	73.7 (10)	75 (10)	62.5 (10)
width of thorax at top	87.5	77 (10)	87.5 (10)	70 (10)
width of thorax at base	112.5	106 (10)	125 (10)	75 (10)
length of horn	75	75.5 (10)	87.5 (10)	67.5 (10)
width of horn at base	25	23.7 (10)	25 (10)	20 (10)
length of foot (maximum)	112.5	104.6 (10)	112.5 (10)	100 (10)

Type locality.—MX-81-54 (see *Appendix*).

Deposition of types.—Holotype: USNM 379308; paratypes: USNM 379309 and Pessagno Collection.

Range and occurrence.—Upper Jurassic: lower Tithonian portion of Taman Formation, east-central Mexico. Tethyan Realm (Text-figs. 6, 7).

Napora cerromesaensis, new species
Plate 4, figures 2–4, 10, 15, 16

Etymology.—This species is named for Cerro Mesa, located to the northeast of its type locality.

Diagnosis.—Cephalis relatively small, hemispherical, with massive apical horn; cephalis may be partially obscured by a thin layer of microgranular silica. Horn approximately same length as test, triradiate in axial section with narrow, rounded, longitudinal ridges alternating with broad, deep grooves; ridges extended into broad spines midway from base to terminus of horn; narrow ridges of apical horn may extend down over cephalis, although not as pronounced as on horn; horn tapers distally. Thorax subpyramidal in shape with large, irregularly-shaped tetragonal and pentagonal pore frames arranged in poorly-defined transverse rows. Massive triradiate feet attached to base of thorax, curved slightly inward. Mouth subtriangular in outline, surrounded by imperforate rim.

Remarks.—*Napora cerromesaensis,* n. sp., is distinguished from *Napora* (?) *graybayensis,* n. sp., by the more regular arrangement of the pore frames and the thin layer of microgranular silica on the cephalis. In addition, *N. cerromesaensis* possesses a more massive horn and feet that are not as curved as those of *N.*(?) *graybayensis,* n. sp.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	20	16.8 (11)	20 (11)	15 (11)
length of thorax	80	70.5 (10)	80 (10)	60 (10)
width of thorax at top	40	38.1 (11)	45 (11)	30 (11)
width of thorax at base	90	99.5 (11)	110 (11)	90 (11)
length of horn	70	86.3 (11)	100 (11)	70 (11)
width of horn at base	20	22.7 (11)	25 (11)	20 (11)
length of foot (maximum)	80	95.9 (11)	120 (11)	70 (11)

Type locality.—BPW-30 (see *Appendix*).

Deposition of types.—Holotype: USNM 379321; paratypes: USNM 379322 and Pessagno Collection.

Range.—Lower Jurassic: upper Pliensbachian, so far as known (Text-fig. 7).

Occurrence.—San Hipólito Formation, sandstone member, Baja California Sur. ?Boreal Realm. Nicely Formation, east-central Oregon. Tethyan Realm (Text-fig. 5).

Napora cosmica, new species
Plate 7, figures 2, 5–7, 19, 21, 22; Plate 11, figure 10

Etymology.—(L.) *cosmicos* = belonging to the world.

Diagnosis.—Cephalis small, hemispherical, with medium-length horn. Horn basically triradiate in axial section, having three wide ridges alternating with three shallow, wide grooves. Proximal two-thirds of horn with subsidiary grooves developed on primary ridges (Pl. 7, figs. 19, 22) resulting from bifurcation of a given primary ridge. Distal one-third of horn with the development of short, nodelike spines (usually three) on primary ridges. Thorax pyramidal with variably-sized pentagonal and hexagonal pore frames and very long curved feet (Pl. 7, figs. 2, 5). Feet triradiate in axial section with three wide grooves alternating with three narrow ridges. Ridges higher in relief on proximal half of a given foot. Proximal half of each foot curving outwards away from axis of test; distal half of each foot curving towards the axis of test growth.

Remarks.—This species differs from other species of *Napora* by virtue of its long, peculiarly-curved feet.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	20	20.5 (9)	25 (9)	20 (9)
length of thorax	50	55.5 (9)	65 (9)	45 (9)
width of thorax at top	50	48.8 (9)	55 (9)	40 (9)
width of thorax at base	117.5	105.2 (9)	120 (9)	90 (9)
length of horn	50	55.5 (9)	85 (9)	40 (9)
width of horn at base	22.5	24.4 (9)	30 (9)	20 (9)
length of foot (maximum)	125	112.7 (9)	135 (9)	85 (9)

Type locality.—OR-513 (see *Appendix*).

Deposition of types.—Holotype: USNM 379323; paratypes: USNM 379324 and Pessagno Collection.

Range.—Middle Jurassic: lower upper Bajocian (Text-fig. 7).

Occurrence.—South Fork Member of the Snowshoe Formation, east-central Oregon. Tethyan Realm (Text-fig. 6).

Napora species aff. **N. cosmica**, new species
Plate 6, figure 8

Remarks.—This form closely resembles *N. cosmica,* n. sp., but differs by having a smaller thorax with less numerous pore frames.

Range and occurrence.—Middle Jurassic (Aalenian?). Warm Springs Member of the Snowshoe Formation (loc. OR-580; rare). Tethyan Realm (Text-figs. 6, 7).

Napora deweveri Baumgartner, *sensu lato*
Plate 10, figure 14

Napora deweveri Baumgartner, 1980b, pp. 56–57, pl. 3, figs. 1–3, 5; pl. 6, fig. 9.

Remarks.—Our specimens of *N. deweveri* appear to possess slightly larger thoracic pores and a longer horn than displayed by Baumgartner's types. We see no evidence of a cephalocone on either Baumgartner's specimens or ours.

Range and occurrence.—Upper Jurassic: lower Tithonian. Taman Formation of east-central Mexico. Tethyan Realm (Text-figs. 6, 7).

Napora species aff. **N. deweveri** Baumgartner
Plate 10, figure 19

Range and occurrence.—Upper Jurassic: lower Tithonian. Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984) loc. MX-82-20. Taman Formation of east-central Mexico. Tethyan Realm (Text-figs. 6, 7).

Napora fructuosa, new species
Plate 6, figures 1–3; Plate 11, figure 6

Etymology.—(L.) *fructuosus* = fertile.

Diagnosis.—Cephalis low, broad, hemispherical, with short, stout horn; horn triradiate in axial section with three broad ridges alternating with three narrow grooves. Thorax broad, hemispherical, with numerous small, slightly nodose pentagonal and hexagonal pore frames. Feet very narrow, long, incurved, triradiate in axial section with three narrow longtitudinal ridges alternating with three narrow grooves.

Remarks.—*Napora fructuosa,* n. sp., differs from *N. lospensis* Pessagno, 1977a, by having smaller, much less massive pore frames, a less massive horn, and longer, considerably thinner feet.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	25 (10)	25 (10)	25 (10)
length of thorax	100	82.5 (10)	100 (10)	50 (10)
width of thorax at top	75	70.7 (10)	75 (10)	50 (10)
width of thorax at base	117.5	106.5 (10)	117.5 (10)	97.5 (10)
length of horn	25	22.5 (10)	25 (10)	12.5 (10)
width of horn at base	50	46.1 (10)	50 (10)	37.5 (10)
length of foot (maximum)	100	93.3 (6)	125 (6)	62.5 (6)

Type locality.—OR-593 (see *Appendix*).

Deposition of types.—Holotype: USNM 379325; paratypes: USNM 379326 and Pessagno Collection.

Range.—Lower Jurassic: Middle Jurassic: Aalenian (Text-fig. 7).

Occurrence.—Warm Springs Member, Snowshoe Formation, east-central Oregon. Tethyan Realm (Text-figs. 5, 6).

Napora (?) **graybayensis**, new species
Plate 2, figures 1–3, 10, 11, 14; Plate 11, figures 3, 4

Etymology.—This species is named for Gray Bay, which is located north of its type locality.

Diagnosis.—Cephalis relatively small, hemispherical, with massive horn; pore frames of cephalis commonly not covered by layer of microgranular silica. Horn triradiate in axial section throughout most of its length, with three narrow, rounded, longitudinal ridges alternating with three broad, shallow grooves; horn tapering sharply distally; length of horn one-half to equal to length of test; small spines commonly located on ridges approximately at midpoint of horn. Thorax subpyramidal in shape with medium- to very large-

sized, irregularly-shaped, tetragonal to pentagonal pore frames; pore frames arranged in poorly-defined transverse rows with slight development of transverse ridges separating the rows. Feet of moderate length, curved inward, triradiate in cross-section, consisting of three very narrow, longitudinal ridges alternating with broad shallow grooves. Mouth triangular in outline, bounded by narrow, imperforate rim.

Remarks.—This species of *Napora* is distinguished from others by the irregular shape and distribution of the pore frames. It is questionably assigned to the genus *Napora* because of its peculiar, irregular pore frames, poor definition externally between the cephalis and thorax, and the lack of a microgranular layer proximally.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	10	13.3 (9)	20 (9)	10 (9)
length of thorax	50	56.6 (9)	75 (9)	45 (9)
width of thorax at top	30	36.6 (9)	45 (9)	30 (9)
width of thorax at base	50	69.4 (9)	80 (9)	50 (9)
length of horn	50	42.2 (7)	60 (7)	30 (7)
width of horn at base	12.5	14.1 (9)	20 (9)	10 (9)
length of foot (maximum)	30	65 (8)	80 (8)	45 (8)

Type locality.—QC-675 (see *Appendix*).

Deposition of types.—Holotype: USNM 379327; paratypes: USNM 379328 and Pessagno Collection.

Range.—Upper Sinemurian, so far as known (Text-fig. 7).

Occurrence.—Kunga Formation, black argillite member, Queen Charlotte Islands, British Columbia. Tethyan Realm (Text-fig. 5).

Napora heimi, new species
Plate 10, figures 8, 10–12, 17, 20, 24

Etymology.—This species is named for Arnold Heim, in honor of his pioneering investigations of the geology of the Sierra Madre Oriental in the early 1900's.

Diagnosis.—Cephalis relatively large, hemispherical, with very wide, massive horn of medium length. Horn triradiate in axial section with three eccentric grooves alternating with three eccentric ridges; grooves wide medially, lenticular in outline; ridges wide, massive, gradually becoming narrower distally; ridges higher in relief and developing nodes in middle portion of horn, lending a swollen appearance to horn medially. Cephalis and proximal portion of horn may be covered by layer of microgranular silica. Thorax rounded, hemispherical, with symmetrical, medium-sized, slightly-nodose pentagonal and hexagonal pore frames. Feet triradiate in axial section and of medium length, curved slightly towards long axis of test; feet consisting of three medium-width longitudinal grooves alternating with three rounded, medium-width ridges.

Remarks.—*Napora heimi,* n. sp., appears closely related to *Napora deweveri* Baumgartner, 1980b. It differs from *N. deweveri* by having a horn that is longer, with wide grooves of lenticular outline; by having a rounded, hemispherical thorax; by having larger and less numerous pore frames; and by having longer, less curved feet that possess ridges which are rounded rather than bladelike.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	27.5	25.2 (10)	27.5 (10)	25.5 (10)
length of thorax	62.5	71 (10)	75 (10)	62.5 (10)
width of thorax at top	75	73.7 (10)	80 (10)	62.5 (10)
width of thorax at base	100	101.2 (10)	112.5 (10)	100 (10)
length of horn	77.5	71.7 (10)	77.5 (10)	57.5 (10)
width of horn at base	32.5	29.5 (10)	37.5 (10)	25 (10)
length of foot (maximum)	75	84.6 (8)	100 (8)	72.5 (8)

Type locality.—MX-81-54 (see *Appendix*).

Deposition of types.—Holotype: USNM 379329; paratypes: USNM 379330 and Pessagno Collection.

Range and occurrence.—Upper Jurassic: lower Tithonian part of the Taman Formation, east-central Mexico. Tethyan Realm (Text-figs. 6, 7).

Napora species aff. **N. heimi**, new species
Plate 10, figure 13

Remarks.—This form differs from *Napora heimi,* n. sp., by having a thorax with irregular polygonal pore frames.

Range and occurrence.—Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984). Upper Jurassic: lower Tithonian part of the Taman Formation, east-central Mexico. Tethyan Realm (Text-figs. 6, 7).

Napora horrida, new species
Plate 6, figures 16, 20; Plate 11, figure 5

Etymology.—(L.) *horridus* = horrible, uncouth.

Diagnosis.—Cephalis hemispherical, with large cephalocone and massive medium-length horn. Horn triradiate in axial section with three wide, rounded, longitudinal ridges alternating with three wide, longitudinal grooves. Ridges more or less parallel on proximal half

of horn, converging on distal half, maintaining same width throughout; each ridge with short nodose spine medially. Thorax subpyramidal with large, slightly nodose, irregularly-shaped tetragonal, pentagonal, and hexagonal pore frames. Feet wide, massive, short, straight, triradiate in axial section, projecting slightly outwards. Feet with three thin, rounded, moderately high longitudinal ridges that alternate with three longitudinal grooves; grooves very wide proximally, wedging out in a distal direction; ridges decreasing slightly in width distally.

Remarks.—*Napora horrida,* n. sp., differs from *N. bearensis,* n. sp., by possessing a longer, wider, structurally-different horn; by possessing a mixture of tetragonal, pentagonal, and hexagonal pore frames; and by possessing shorter, wider, straighter feet.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	17.5	24 (8)	25 (8)	17.5 (8)
length of thorax	62.5	70.3 (8)	100 (8)	50 (8)
width of thorax at top	50	53.7 (8)	75 (8)	50 (8)
width of thorax at base	100	102.1 (8)	122.5 (8)	75 (8)
length of horn	32.5	44.6 (8)	55 (8)	32.5 (8)
width of horn at base	20	23.7 (8)	27.5 (8)	20 (8)
length of foot (maximum)	82.5	97.5 (5)	112.5 (5)	82.5 (5)

Type locality.—OR-555 (see *Appendix*).

Deposition of types.—Holotype: USNM 379331; paratypes: USNM 379332 and Pessagno Collection.

Range.—Middle Jurassic: lower Bajocian (Text-fig. 7).

Occurrence.—Warm Springs Member of the Snowshoe Formation of east-central Oregon. Tethyan Realm (Text-fig. 6).

Napora insolita, new species
Plate 5, figures 5, 12, 13

Etymology.—(L.) *insolitus* = unusual, strange.

Diagnosis.—Cephalis small, hemispherical; cephalocone moderately well-developed with slitlike pores; horn short, triradiate with three narrow ridges alternating with three wide grooves, each ridge terminating with short spikelike node at tip of horn. Thorax conical in outline, comprised predominantly of pentagonal and hexagonal pore frames. Three feet of medium length, triradiate in axial section with three narrow ridges alternating with three wide grooves.

Remarks.—*Napora insolita,* n. sp., differs from other species of *Napora* described in this paper by having a short horn with spikelike nodes at tip.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	31 (8)	40 (8)	25 (8)
length of thorax	65	62 (8)	75 (8)	50 (8)
width of thorax at top	60	59 (8)	75 (8)	50 (8)
width of thorax at base	125	115 (8)	125 (8)	100 (8)
length of horn	50	47 (8)	60 (8)	35 (8)
width of horn at base	30	23 (8)	30 (8)	20 (8)
length of foot (maximum)	125	96 (7)	130 (7)	80 (7)

Type locality.—OR-589 (see *Appendix*).

Deposition of types.—Holotype: USNM 379333; paratypes: USNM 379334 and Pessagno Collection.

Range.—Lower Jurassic: upper Pliensbachian to middle Toarcian (Text-fig. 7).

Occurrence.—Nicely Formation, Hyde Formation and the Warm Springs Member of the Snowshoe Formation, east-central Oregon. Tethyan Realm (Text-fig. 5).

Napora izeensis, new species
Plate 8, figures 1, 7–9, 11, 16; Plate 11, figure 8

Etymology.—This species is named for the settlement of Izee, which is located near its type locality.

Diagnosis.—Cephalis small, hemispherical, with medium-length, delicate, sharply-pointed horn. Proximal two-thirds of horn triradiate in axial section; distal one-third circular in axial section. Three longitudinal grooves lenticular in outline on proximal two-thirds of horn; three ridges wider and more massive proximally, flaring outwards to form three nodelike spines; beyond position of nodelike spines, ridges thinner, converging and merging on distal one-third of horn. Thorax hemispherical with mixture of weakly-nodose, medium-sized pentagonal and hexagonal pore frames. Feet long, pointed, slender, triradiate; proximal half of a given foot flaring slightly outwards, extending almost directly beneath thorax; distal half of a given foot somewhat curved inwards towards long axis of test growth. Feet with three narrow, high longitudinal ridges alternating with three wide, deep grooves; grooves about two times wider than ridges. Ridges and grooves gradually decreasing in width distally.

Remarks.—*Napora izeensis,* n. sp., differs from other species of *Napora* by virtue of the distinctive structure of its horn and the long, very slender nature of its feet. Whereas the proximal two-thirds of the horn are triradiate in axial section, the distal one-third is circular in axial section and lacks alternating ridges and grooves. Furthermore, the three nodelike spines present medially appear to have formed from the outward flaring of the ridges.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	26 (10)	30 (10)	25 (10)
length of thorax	87.5	79.5 (10)	100 (10)	65 (10)
width of thorax at top	75	69.5 (10)	87.5 (10)	60 (10)
width of thorax at base	150	132.2 (10)	150 (10)	120 (10)
length of horn	125	93.3 (9)	125 (9)	75 (9)
width of horn at base	25	25 (10)	30 (10)	20 (10)
length of foot (maximum)	175	140 (5)	175 (5)	100 (5)

Type locality.—Holotype from loc. OR-501B; paratypes from locs. OR-501A, OR-501B.

Deposition of types.—Holotype: USNM 379335; paratypes: USNM 379336 and Pessagno Collection.

Range and occurrence.—South Fork Member of the Snowshoe Formation, east-central Oregon. Middle Jurassic: upper Bathonian so far as known. Boreal Realm (Text-figs. 6, 7).

Napora lospensis Pessagno
Plate 9, figures 11, 16

Napora lospensis Pessagno, 1977a, p. 96, pl. 12, figs. 9–10; not Baumgartner, De Wever and Kocher, 1980, p. 57, pl. 3, fig. 4.

Remarks.—The form figured by Baumgartner, De Wever, and Kocher (1980) as *Napora lospensis* Pessagno bears no resemblance to Pessagno's figured holotype. It possesses a longer, structurally different horn; longer, less massive feet; and less massive pore frames. This form should probably be assigned to *Napora bukryi* Pessagno, 1977a.

Deposition of types.—Holotype: USNM 22004.

Range.—Upper Zone 2 to Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984).

Occurrence.—Volcanogenic-pelagic strata (Boreal strata only) overlying the Coast Range ophiolite. Boreal Realm.

Napora maritima, new species
Plate 7, figures 3, 4, 13, 23; Plate 11, figure 2

Etymology.—(L.) *maritimus* = of the sea.

Diagnosis.—Cephalis large, hemispherical, with short horn. Horn triradiate in axial section with three wide, shallow, lenticular grooves alternating with three medium-width, rounded longitudinal ridges; ridges each with well-developed node medially. Thorax inflated, hemispherical, with medium-sized, weakly-nodose pentagonal and hexagonal pore frames comprised of relatively wide bars. Feet triradiate in axial section, quite long and relatively straight projecting outwards from base of thorax with three narrow grooves alternating with three rounded ridges. Ridges gradually decreasing in width distally; grooves maintaining about same width throughout.

Remarks.—*Napora maritima,* n. sp., differs from *N. baumgartneri,* n. sp., by having longer, straighter feet that are not inturned. Furthermore, whereas the feet of *N. baumgartneri* possess ridges that increase considerably in relief distally and become bladelike, those of *N. maritima* remain about the same height throughout and tend to be rounded.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	22.5	23.4 (8)	25 (8)	20 (8)
length of thorax	75	65 (8)	75 (8)	50 (8)
width of thorax at top	50	50 (8)	62.5 (8)	42.5 (8)
width of thorax at base	122.5	104 (8)	122.5 (8)	90 (8)
length of horn	52.5	56.2 (8)	70 (8)	50 (8)
width of horn at base	25	24 (8)	25 (8)	20 (8)
length of foot (maximum)	175	152.9 (6)	182.5 (6)	125 (6)

Type locality.—OR-555 (see *Appendix*).

Deposition of types.—Holotype: USNM 379337; paratypes: USNM 379338 and Pessagno Collection.

Range.—Middle Jurassic: lower Bajocian (Text-fig. 7).

Occurrence.—Warm Springs Member of the Snowshoe Formation, east-central Oregon. Tethyan Realm (Text-fig. 6).

Napora mitrata, new species
Plate 5, figures 8, 15; Plate 11, figures 11, 12

Etymology.—(L.) *mitratus* = wearing the mitra, a headdress or turban.

Diagnosis.—Cephalis small, imperforate, and covered with a layer of microgranular silica. Well-developed cephalocone on cephalis. Horn triradiate in axial section with three ridges alternating with three grooves; horn terminating with moderately long spines pointing upward. Thorax hemispherical in outline, comprised of hexagonal, pentagonal, and tetragonal pore frames with narrow rims and slightly thicker sides. Feet relatively long; triradiate in axial section with three ridges alternating with three grooves, grooves slightly wider than ridges.

Remarks.—*Napora mitrata,* n. sp., differs from *N. insolita,* n. sp., by having much longer spines at tip of horn.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	28 (8)	35 (8)	25 (8)
length of thorax	63	73 (8)	75 (8)	63 (8)
width of thorax at top	50	50 (8)	60 (8)	40 (8)
width of thorax at base	120	114 (8)	125 (8)	100 (8)
length of horn	63	62 (8)	75 (8)	50 (8)
width of horn at base	25	23 (8)	25 (8)	20 (8)
length of foot (maximum)	150	149 (8)	190 (8)	110 (8)

Type locality.—OR-600 (see *Appendix*).

Deposition of types.—Holotype: USNM 379339; paratypes: USNM 379340 and Pessagno Collection.

Range.—Lower Jurassic: lower Toarcian (Text-fig. 7).

Occurrence.—The Hyde Formation, east-central Oregon. Tethyan Realm (Text-fig. 6).

Napora moctezumaensis, new species
Plate 9, figures 8–10, 20–22

Etymology.—This species is named for the Río Moctezuma, which flows through the type area of the Taman Formation.

Diagnosis.—Cephalis small, hemispherical, with relatively long, distinctive horn. Proximal half of horn triradiate in axial section with three massive, parallel, rounded longitudinal ridges alternating with three longitudinal grooves; ridges and grooves about equal in width. Distal half of horn circular in axial section about one-half to one-third the diameter of proximal half. Thorax hemispherical with medium-sized pentagonal and hexagonal pore frames; pentagonal pore frames predominating. Feet of medium length, very slender, triradiate in axial section with three narrow grooves alternating with three narrow ridges.

Remarks.—*Napora moctezumaensis,* n. sp., differs from *N. burckhardti,* n. sp., by having a hemispherical, proportionally smaller thorax (rather than a subcylindrical thorax) with fewer pore frames; by having slender, less massive feet, and a somewhat less massive but structurally similar horn. Similarities in horn structure suggest that *N. moctezumaensis, N. burckhardti,* n. sp., and *N. boneti,* n. sp., may be phylogenetically related.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	25 (9)	25 (9)	25 (9)
length of thorax	75	75 (9)	75 (9)	75 (9)
width of thorax at top	75	70.8 (9)	75 (9)	62.5 (9)
width of thorax at base	100	103.3 (9)	120 (9)	97.5 (9)
length of horn	87.5	76.9 (9)	100 (9)	55 (9)
width of horn at base	25	24.2 (9)	27.5 (9)	20 (9)
length of foot (maximum)	87.5	85.4 (7)	100 (7)	75 (7)

Type locality.—MX-82-8 (see *Appendix*).

Deposition of types.—Holotype: USNM 379341; paratypes: USNM 379342 and Pessagno Collection.

Range.—Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984). Upper Jurassic: uppermost lower Kimmeridgian?; lowermost upper Kimmeridgian (Text-fig. 7).

Occurrence.—Taman Formation of east-central Mexico. Tethyan Realm (Text-fig. 6).

Napora species aff. **N. moctezumaensis**, new species
Plate 9, figures 6, 15

Remarks.—This form appears to be closely related to *Napora moctezumaensis,* n. sp. It differs from the latter species by having a shorter horn and much shorter, more slender feet.

Range and occurrence.—Taman Formation of east-central Mexico; uppermost lower Kimmeridgian or lower upper Kimmeridgian (loc. MX-82-8; rare). Tethyan Realm (Text-figs. 6, 7).

Napora morganensis, new species
Plate 3, figures 3, 8, 10, 11, 15

Etymology.—This species is named for Morgan Mountain, which is located at its type locality.

Diagnosis.—Cephalis hemispherical, medium-sized with long horn that is triradiate in axial section. Horn with three medium-width longitudinal ridges alternating with three medium-width grooves; grooves and

ridges maintaining about the same width throughout; tip of horn rounded, somewhat blunt in appearance. Thorax hemispherical with a mixture of medium-sized, massive pentagonal and hexagonal pore frames. Feet straight, very long, triradiate in axial section with three relatively wide longitudinal ridges alternating with three narrow longitudinal grooves; grooves and ridges maintaining same width except on distal portions of feet where they tend to become progressively narrower.

Remarks.—*Napora morganensis,* n. sp., differs from other species of *Napora* by having a long, straight horn with a bluntly rounded tip and very long, straight feet. Furthermore, whereas most species of *Napora* possess horns with short spines or nodes along their longitudinal ridges, *N. morganensis* lacks such structures.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	25 (9)	25 (9)	25 (9)
length of thorax	62.5	65.2 (9)	70 (9)	55 (9)
width of thorax at top	75	64.7 (9)	75 (9)	57.5 (9)
width of thorax at base	100	109.7 (9)	125 (9)	100 (9)
length of horn	75	87.5 (5)	100 (5)	75 (5)
width of horn at base	20	24.3 (8)	25 (8)	20 (8)
length of foot (maximum)	187.5	165 (8)	187.5 (8)	150 (8)

Type locality.—OR-536 (see *Appendix*).

Deposition of types.—Holotype: USNM 379343; paratypes: USNM 379344 and Pessagno Collection.

Range.—Lower Jurassic: upper Pliensbachian (Text-fig. 7).

Occurrence.—Nicely Formation of east-central Oregon. Tethyan Realm (Text-fig. 5).

Napora opaca, new species
Plate 6, figures 14, 17, 18, 21

Etymology.—(L.) *opacus* = shadowy, obscure.

Diagnosis.—Cephalis small, hemispherical, with relatively short horn. Horn triradiate in axial section with three grooves alternating with three rounded ridges; ridges of medium width on proximal two-thirds of horn, decreasing slightly in width distally and giving rise to a weakly-developed nodelike spine on each ridge. Distal one-third of horn with shallow grooves and weakly-developed ridges. Thorax inflated, hemispherical, with mixture of medium- to small-sized pentagonal pore frames and medium-sized hexagonal pore frames. Three feet flaring slightly outwards below thorax and inturned distally; feet triradiate in axial section, consisting of three medium-width, rounded ridges alternating with three medium-width, relatively deep grooves; grooves and ridges about same width, gradually decreasing in width in a distal direction.

Remarks.—*Napora opaca,* n. sp., is closely linked phylogenetically to *N. baumgartneri,* n. sp., and *N. maritima,* n. sp. All three species display horns with similar structure and similar thoracic segments. *N. opaca* differs from *N. baumgartneri* by having narrower feet that have longitudinal ridges of much lower relief and that are not so markedly curved. *N. opaca* differs from *N. maritima* by having feet that are considerably shorter, not so widely-spread, and more curved.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	26.5 (8)	37.5 (8)	25 (8)
length of thorax	75	80.3 (8)	100 (8)	75 (8)
width of thorax at top	62.5	62.5 (8)	75 (8)	50 (8)
width of thorax at base	120	129.6 (8)	137.5 (8)	120 (8)
length of horn	55	56.2 (8)	62.5 (8)	45 (8)
width of horn at base	25	24 (8)	25 (8)	20 (8)
length of foot (maximum)	125	118.7 (8)	150 (8)	100 (8)

Type locality.—OR-594 (see *Appendix*).

Deposition of types.—Holotype: USNM 379345; paratypes: USNM 379346 and Pessagno Collection.

Range.—Middle Jurassic: lower Bajocian (Text-fig. 7).

Occurrence.—Warm Springs Member of the Snowshoe Formation. Tethyan Realm (Text-fig. 6).

Napora tumultuosa, new species
Plate 9, figures 1, 2, 7, 18

Etymology.—(L.) *tumultuosus* = confused, disturbed.

Diagnosis.—Cephalis medium-sized, hemispherical, with triradiate asymmetrical horn of medium length. Proximal half to one-third of horn with three wide, massive, rounded, curved ridges that suddenly terminate in the form of short spines; ridges on proximal half to one-third of horn alternating with three deep grooves that are of about the same width as the ridges. Ridges on distal one-half to one-third of horn about half as wide and lower in relief than ridges on proximal half of horn; ridges separated by three narrow, shallow grooves. Thorax hemispherical with deep

irregular tetragonal and triangular pore frames that possess narrow bars and small nodes at vertices. Feet relatively long, broad, incurved, triradiate in axial section, composed of three narrow bladelike ridges that are very high in relief; ridges alternate with three wide grooves.

Remarks.—*Napora tumultuosa,* n. sp., differs from all other species of *Napora* by the peculiar structure of its horn, coupled with the irregular nature of its thoracic pore frames and the structure of its feet.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	25.3 (8)	27.5 (8)	25 (8)
length of thorax	50	54.3 (8)	62.5 (8)	50 (8)
width of thorax at top	62.5	66.2 (8)	87.5 (8)	62.5 (8)
width of thorax at base	112.5	101.8 (8)	125 (8)	100 (8)
length of horn	82.5	74.2 (7)	87.5 (7)	62.5 (7)
width of horn at base	25	24.6 (8)	25 (8)	22.5 (8)
length of foot (maximum)	112.5	109.3 (4)	125 (4)	100 (4)

Type locality.—Holotype from loc. OR-501B. Paratypes from locs. OR-501B, OR-501A (see *Appendix*).

Deposition of types.—Holotype: USNM 379347; paratypes: USNM 379348 and Pessagno Collection.

Range and occurrence.—South Fork Member of the Snowshoe Formation. Middle Jurassic: upper Bathonian so far as known. Boreal Realm (Text-figs. 6, 7).

Napora turgida, new species
Plate 6, figures 9, 10; Plate 11, figure 17

Etymology.—(L.) *turgidus* = swollen.

Diagnosis.—Cephalis large, hemispherical, with relatively massive, triradiate horn of medium length; horn with three wide, deep grooves alternating with three medium-width ridges; ridges each with single, medially-placed node. Thorax large, very inflated, hemispherical with mixture of variably-sized, non-nodose pentagonal and hexagonal pore frames. Pore frames shallow with thin bars. Feet triradiate, wide proximally, incurved, of medium length with three medium-width grooves alternating with three medium-width ridges; ridges and grooves gradually decreasing in width distally.

Remarks.—*Napora turgida,* n. sp., differs from *N. antelopensis,* n. sp., by having a more massive horn, wider, more incurved feet, and shallower, more symmetrical pore frames.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	23.7 (10)	25 (10)	20 (10)
length of thorax	75	73 (10)	87.5 (10)	50 (10)
width of thorax at top	75	60 (10)	75 (10)	37.5 (10)
width of thorax at base	125	107.5 (10)	125 (10)	75 (10)
length of horn	50	50.7 (10)	55 (10)	45 (10)
width of horn at base	25	23.7 (10)	25 (10)	20 (10)
length of foot (maximum)	77.5	82.5 (6)	92.5 (6)	75 (6)

Type locality.—OR-555 (see *Appendix*).

Deposition of types.—Holotype: USNM 379349; paratypes: USNM 379350 and Pessagno Collection.

Range.—Middle Jurassic: Aalenian to lower Bajocian (Text-fig. 7).

Occurrence.—Warm Springs Member of the Snowshoe Formation of east-central Oregon. Tethyan Realm (Text-fig. 6).

Napora vegaensis, new species
Plate 9, figure 24; Plate 11, figure 16

Etymology.—This species is named for the village of La Vega, which is located near its type locality.

Diagnosis.—Cephalis broad, hemispherical, with short massive horn. Horn triradiate in axial section with three deep, narrow longitudinal grooves; primary ridges developing subsidiary grooves proximally. Thorax hemispherical, almost subcylindrical with medium-sized, symmetrical pentagonal and hexagonal pore frames; base of thorax with prominent rounded, arched imperforate ridge occurring between two given feet and merging with innermost longitudinal ridges of feet. Feet long, thick, straight, triradiate in axial section, with three massive, rounded longitudinal ridges that alternate with three deep longitudinal grooves. Ridges somewhat wider than grooves, both becoming gradually narrower in a distal direction.

Remarks.—*Napora vegaensis,* n. sp., differs from *N. burckhardti,* n. sp., by having a shorter horn that is completely triradiate in axial section, a thorax that is less elongate and less cylindrical, and feet that are much thicker, more massive, and straighter.

Measurements (in μm).—Numbers of specimens measured are in parentheses.

	holotype	*mean*	*maximum*	*minimum*
length of cephalis	25	25 (10)	25 (10)	25 (10)
length of thorax	100	94 (10)	100 (10)	77.5 (10)
width of thorax at top	75	71.2 (10)	75 (10)	50 (10)
width of thorax at base	100	103.2 (10)	117.5 (10)	100 (10)
length of horn	37.5	42.8 (8)	50 (8)	37.5 (8)
width of horn at base	27.5	22.2 (9)	27.5 (9)	20 (9)
length of foot (maximum)	100	117.5 (10)	142.5 (10)	100 (10)

Type locality.—MX-82-8 (see *Appendix*).

Deposition of types.—Holotype: USNM 379351; paratypes: USNM 379352 and Pessagno Collection.

Range.—Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984). Upper Jurassic: upper lower Kimmeridgian/upper Kimmeridgian (Text-fig. 7).

Occurrence.—Taman Formation of east-central Mexico. Tethyan Realm (Text-fig. 6).

Napora species A
Plate 7, figure 14

Range and occurrence.—Middle Jurassic (lower Bajocian). Warm Springs Member of the Snowshoe Formation of east-central Oregon (loc. OR-554; rare). Tethyan Realm.

Napora species B
Plate 7, figure 8

Range and occurrence.—Middle Jurassic: lower Bajocian. Warm Springs Member of the Snowshoe Formation of east-central Oregon (loc. OR-516; rare). Tethyan Realm.

Napora species C
Plate 10, figure 6

Range and occurrence.—Upper Jurassic: Kimmeridgian. This form has been observed in volcanogenic-pelagic strata overlying the Coast Range ophiolite at Point Sal, Santa Barbara County (loc. NSF-907: upper part of Zone 2, *sensu* Pessagno, Blome, and Longoria, 1984). It also occurs in sample POB 889 (of Baumgartner [see Baumgartner, De Wever, and Kocher, 1980, p. 65]) from Greece. Its known distribution thus appears to be Southern Boreal to Central Tethyan.

Napora species D
Plate 6, figure 12

Remarks.—This form is similar to *Napora horrida,* n. sp. It differs from the latter species by having smaller, more symmetrical and constant-sized pore frames and by having feet that are shorter and structurally different.

Range and occurrence.—Middle Jurassic (Aalenian?). Warm Springs Member of the Snowshoe Formation, east-central Oregon (loc. OR-593). Tethyan Realm.

Napora species E
Plate 10, figure 18

Range and occurrence.—Zone 4 (*sensu* Pessagno, Blome, and Longoria, 1984). Upper Jurassic: upper Tithonian. Taman Formation of east-central Mexico (loc. MX-82-37). Tethyan Realm.

Napora species F
Plate 10, figure 9

Range and occurrence.—Zone 4 (*sensu* Pessagno, Blome, Longoria, 1984). Upper Jurassic: upper Tithonian. Taman Formation of east-central Mexico. Broken forms that appear correlative with this form have been observed in upper Tithonian strata in the California Coast Ranges (loc. MX-82-37). Tethyan Realm, ?Boreal Realm.

Napora species G
Plate 10, figure 7

Range and occurrence.—Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984). Upper Jurassic: lower Tithonian (loc. MX-81-54). Tethyan Realm.

Napora species H
Plate 7, figure 9

Range and occurrence.—Middle Jurassic: upper Bajocian. Snowshoe Formation (undifferentiated) of east-central Oregon (loc. OR-550). Tethyan Realm.

APPENDIX—LOCALITY DESCRIPTIONS

Introduction

Localities in each geographic area are listed in ascending order chronostratigraphically or biostratigraphically. Formational units are discussed in the text (see *Tectonostratigraphy*).

The following letter prefixes are used:

MX = east-central Mexico (San Luis Potosí).
OR = Mesozoic clastic terrane, John Day Inlier, east-central Oregon.
NSF, JP, SA = California Coast Ranges.
BPW, SH = Vizcaino Peninsula, Baja California Sur, Mexico.
QC = Queen Charlotte Islands, British Columbia, Canada.

EAST-CENTRAL OREGON, JOHN DAY INLIER SUPLEE–IZEE AREA OF DICKINSON AND VIGRASS (1965), AND ADJOINING AREAS

Lower Jurassic

OR-536*.—Nicely Formation. Reddish-brown weathering, dark-gray, silty mudstone and shale with abundant dark-gray to black, micritic limestone nodules varying in diameter from 15 cm to 0.9 m (6 in to 3 ft). Abundant well-preserved pyritized Radiolaria arranged concentrically in flattened nodules about 7.5 cm (3 in) in diameter; 13.1 to 16.4 m (40 to 50 ft) above the base of the Nicely Formation. U. S. G. S. Izee 15′ Quadrangle: T.17S., R.27E., NE ¼ of sect. 14. Southeast side of Morgan Mountain; small creek west of Elkhorn Creek.

Upper Pliensbachian; equivalent to *margaritatus* and *spinatum* zones (ammonite standard zones: see Imlay, 1968).

OR-600.—Hyde Formation. Massive, medium-gray, volcaniclastic sandstone (volcanic wacke) with occasional thin interbeds of tuffaceous mudstone and siltstone. Well-preserved silicified Radiolaria occurring in small, dark-gray, micritic limestone nodules about 7.5 cm (3 in) in diameter. 64 m (210 ft) above base of Hyde Formation. U. S. G. S. Izee 15′ Quadrangle: T.17S., R.28E., SW ¼ of sect. 30. State highway 63 (Izee–Paulina road) along South Fork of John Day River just west of bridge over river (turn off to Hole-in-the-Ground). Upper Pliensbachian(?); lower Toarcian; upper Toarcian(?).

OR-589.—Warm Springs Member, Snowshoe Formation. Reddish-brown weathering, dark-gray to medium-gray, silty mudstone and shale with limestone nodules bearing well-preserved silicified Radiolaria. Float from interval 1.5 to 3.0 m (5 to 10 ft) above and down hill from the contact with the underlying sandstone of the Hyde Formation. U. S. G. S. Izee 15′ Quadrangle: T.17S., R.28E., NE ¼ of sect. 29 near southern boundary of sect. 20. West side of Schoolhouse Gulch, north-northwest of Izee.

Ammonites from 24.6 and 26.8 m (81, 88 ft) above the contact with the Hyde Formation on the east side of Schoolhouse Gulch were submitted to Dr. Paul Smith (Univ. of British Columbia) for identification. P. L. Smith (written commun., 1982) identified these ammonites as *Dumortieria pusilla* Jaworski, 1926, and indicated that they are correlative with the European *levesquei* Standard Zone (uppermost upper Toarcian). Elsewhere in the same general area, P. L. Smith (written commun., 1982; charts) recorded *Grammoceras* (Hyatt, 1867) *s. l.* from the basal part of the Warm Springs Member and *Dumortieria* sp. cf. *pusilla* Jaworski, 1926, from a horizon approximately 18.2 m (60 ft) above the base of the Warm Springs Member. These fossils were collected by Smith at Caps Creek, 2.5 km (1.7 mi) to the northeast of the Schoolhouse Gulch localities.

The radiolarian assemblage at loc. OR-589 contains *Praeconocaryomma parvimamma* Pessagno and Poisson, 1981. Samples (Pessagno and MacLeod, unpublished data) from 11 to 24 m (35 to 80 ft) above the contact between the Hyde Formation and the Snowshoe Formation at Schoolhouse Gulch lack *P. parvimamma* and contain *Parvicingula* Pessagno, 1977a (*s. l.*) (*sensu* Pessagno and Whalen, 1982) and *Perispyridium tamarackense* Pessagno and Blome, 1982. In the Queen Charlotte Islands, Carter (written commun., 1985) finds that *Parvicingula s. l.* and *Perispyridium* Dumitrica, 1978, make their first appearance in association with ammonites assignable to either the *variabilis* Standard Zone (middle Toarcian) or to the *thouarsense* Standard Zone (upper Toarcian).

Middle Jurassic

OR-593.—Warm Springs Member, Snowshoe Formation. Reddish-brown weathering, dark- to medium-gray, fissile shale with common dark-gray micritic limestone nodules bearing well-preserved silicified Radiolaria. 36.5 m (120 ft) above base of Warm Springs Member. U. S. G. S. Izee 15′ Quadrangle: T.17S., R.28E., SE ¼ of sect. 29; along boundary between sects. 20 and 29 on eastern tributary of Schoolhouse Gulch (north of Izee; Text-fig. 4). This sample is tentatively assigned to the Aalenian.

The radiolarian assemblage at loc. OR-593 contains a few elements such as *Napora fructuosa,* n. sp., that are known in underlying Toarcian strata (*e.g.,* loc. OR-589). In addition, the assemblage at loc. OR-593 lacks lower Bajocian elements such as *Turanta barbara* Pessagno and Blome, 1982, which first appear in strata that are correlative with the *discites* Standard Zone (see loc. OR-555). Loc. OR-593 occurs 11.9 m (39 ft) above the occurrence of upper Toarcian ammonites (see data for loc. OR-589).

OR-580.—Warm Springs Member, Snowshoe Formation. Reddish-brown weathering, dark-gray, fissile shale with dark-gray silty limestone. Position above contact with Hyde Formation difficult to determine because of possible faulting and contortion of beds at contact. U. S. G. S. Izee 15′ Quadrangle: T.17S., R.28E., SW ¼ of sect. 30 near bridge over South Fork of John Day River; about 46 m (150 ft) east of first turn in road to Hole-in-the-Ground.

This sample is tentatively assigned to the Aalenian because it lacks *Turanta barbara* Pessagno and Blome, 1982, and *Perispyridium facetum* Pessagno and Blome, 1982, which are characteristic of lower Bajocian strata bearing ammonites assignable to the *discites, laeviuscula,* and *sauzei* Standard Zones (locs. OR-555, OR-594, OR-595; see below). On the other hand, the ultranaporid taxa present at this locality are more closely allied to those of the lower Bajocian. Significantly, *Napora fructuosa,* n. sp., which is present at loc. OR-593 (Aalenian?) and at loc. OR-589 (Toarcian; see above) is missing. Pessagno and Blome (1982) erroneously stated that loc. OR-580 is situated below a horizon where Imlay (1973) recorded *Tmetoceras scissum* (Benecke, 1865). Unfortunately, Pessagno misread Imlay's faunal list for U. S. G. S. Mesozoic Loc. 26756 (= Loc. D113 of Dickinson and Vigrass, 1965). Imlay (1973, p. 41, table 8) actually recorded *Asthenoceras delicatum* Imlay, 1973, from this locality. Imlay (1973, p. 19) indicated that in Europe *Asthenoceras* Buckman, 1899, occurs in Aalenian strata assignable to the *murchinsonae* Standard Zone. However, in east-central Oregon *Asthenoceras* occurs in lower Bajocian strata assignable to the *discites, laeviuscula,* and *sauzei* Standard Zones (see Imlay, 1973; Smith, 1980). Loc. OR-580 lies approximately along strike with U. S. G. S. Mesozoic Loc. 26756.

OR-555.—Warm Springs Member, Snowshoe Formation. Reddish-brown weathering, dark-gray, fissile shales with dark-gray, micritic limestone nodules and lenticular masses of silty limestone. Limestone nodules commonly bear well-preserved silicified Radiolaria. Sample from loc. OR-555 was collected 70 m (230 ft) above the contact with the underlying Hyde Formation. U. S. G. S. Izee 15′ Quadrangle: T.17S., R.28E., SW ¼ of sect. 1. National Forest Road 16020 near Duncan Hollow; 2.88 km (1.8 mi) west of intersection with state highway 63 (Izee–Paulina road).

P. L. Smith (1980, fig. 6; written commun., 1982; unpublished chart) recorded *Sonninia* (*Euhoploceras*) sp. from a horizon approximately 73 m (240 ft) above the contact with the Hyde Formation and 1.5 m (5 ft) above loc. OR-555. Imlay (1973, pp. 19, 63–68) indicated that *Euhoploceras* Buckman, 1913, occurs in Europe in the *discites* Standard Zone (lowermost Bajocian) and in the *concavum* Standard Zone (uppermost Aalenian). In east-central Oregon *Euhoploceras* has not been observed in Aalenian strata containing *Tmetoceras scissum* (Benecke, 1865); it appears to be restricted to the lowermost Bajocian.

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* This locality was incorrectly cited as being in sec. 12 by Pessagno and Blome (1980).

OR-594.—Warm Springs Member, Snowshoe Formation. Reddish-brown weathering, dark- to medium-gray, fissile shale with dark-gray, micritic limestone nodules containing silicified Radiolaria; 41 m (135 ft) above the contact with the Hyde Formation; in same succession with locs. OR-593 and OR-595. U. S. G. S. Izee 15′ Quadrangle: T.17S., R.28E., SE ¼ of sect. 20; NE ¼ of sect. 29; along boundary between sects. 20 and 29 on eastern tributary to Schoolhouse Gulch.

Ammonites collected 2 m (7 ft) below loc. OR-594 were identified by P. L. Smith (written commun., 1982) as *Lissoceras hydei* Imlay, 1973, *Holcophylloceras* sp., *Pelekodites silviesensis* Imlay, 1973, and *Sonninia*? sp. Smith reported that this assemblage is indicative of his Zone 2 (Smith, 1980, p. 1606), which he equated with the northwestern European *laeviuscula* Standard Zone (upper part) and the *sauzei* Standard Zone (all but uppermost).

Definitive elements in the radiolarian faunal assemblage at this horizon include *Turanta barbara* Pessagno and Blome, 1982, *Perispyridium tamarackense* Pessagno and Blome, 1982, and *Zartus praejonesi* Pessagno and Blome, 1980; these taxa also occur at loc. OR-555 and at loc. OR-595. They do not occur at loc. OR-554, which contains ammonites that are no older than the upper half of the *sauzei* Standard Zone (see below).

OR-595.—Warm Springs Member, Snowshoe Formation. Reddish-brown weathering, dark-gray, fissile shale with common dark-gray, micritic limestone nodules containing well-preserved silicified Radiolaria. 44.2 m (145 ft) above the contact with the underlying Hyde Formation in same section with locs. OR-593, OR-594. U. S. G. S. Izee 15′ Quadrangle: T.17S., R.28E., SE ¼ of sect. 20; NE ¼ of sect. 29; along boundary between sects. 20 and 29 on eastern tributary to Schoolhouse Gulch.

Definitive elements in radiolarian assemblage same as for loc. OR-594. Lower Bajocian (see discussion of megafossil data presented under locs. OR-594, OR-554).

OR-554*.—Warm Springs Member, Snowshoe Formation. Dark-gray shale with dark-gray, micritic limestone nodules; nodules with well-preserved, silicified Radiolaria. Approximately 168 m (550 ft) above base of Warm Springs Member; east of fault of unknown displacement. U. S. G. S. Izee 15′ Quadrangle: T.17S., R.28E., SE ¼ of sect. 1. National Forest Service Road 16020; 0.79 km (1.3 mi) west of intersection with state highway 63 (Izee–Paulina road). Divide between Duncan Hollow and Bunton Creek.

Imlay (1973, p. 41; U. S. G. S. Mesozoic Loc. 28028) recorded *Stephanoceras* (*Skirroceras*) *juhlei* Imlay, 1964b, from this horizon. In the Izee area, Imlay indicated that this species does not range below the upper part of the Warm Springs Member (= lower member of Dickinson and Vigrass, 1965) or above the lower part of the Schoolhouse Member (= middle member of Dickinson and Vigrass, 1965). He indicated (p. 19) that in Europe *Skirroceras* Mascke, 1907, does not range below the base of the *sauzei* Standard Zone or above the top of the *humphriesianum* Standard Zone.

The radiolarian assemblage at loc. OR-554 is characterized by the presence of *Zartus jonesi* Pessagno and Blome, 1980, *Z. jurassicus* Pessagno and Blome, 1980, *Turanta barbara* Pessagno and Blome, 1982, *Perispyridium foremanae* Pessagno and Blome, 1982, *P. facetum* Pessagno and Blome, 1982, and *Parvicingula matura* Pessagno and Whalen, 1982. This horizon occurs above the last appearance of *Perispyridium tamarackense* Pessagno and Blome, 1980, and below the first occurrence of *Zartus imlayi* Pessagno and Blome, 1980.

* Subsequent investigations by Pessagno and MacLeod have led to a revised description of loc. OR-554; hence, data presented by Pessagno and Blome (1980), Pessagno and Whalen (1982), and Pessagno and Blome (1982) should be regarded as obsolete.

OR-516.—Warm Springs Member, Snowshoe Formation (= lower member of Dickinson and Vigrass, 1965). Dark-gray mudstone with common dark-gray, micritic limestone nodules. U. S. G. S. Logdell 15′ Quadrangle: T.16S., R.29E., SE ¼ of sect. 21. Northwest side of state highway 63 (Izee–Paulina road) at elevation of 1585 m (5200 ft); north of Little Snowshoe Creek. 6.2 km (4.2 mi) west of Bear Valley Ranger Station.

This locality corresponds to U. S. G. S. Mesozoic Locality 26773 of Imlay (1973, p. 49) who recorded the following taxa: *Holcophylloceras* sp., *Dorsetensia* sp., *Pelekodites silviesensis* Imlay, 1973, and *Lamellaptychus* sp. *Dorsetensia* Buckman, 1892, ranges from the uppermost part of the *sauzei* Standard Zone to the lower part of the overlying *humphriesianum* Standard Zone in Europe and in their South American equivalents (Smith, 1980, p. 1606; Westermann and Riccardi, 1979, p. 113).

Diagnostic elements in the radiolarian assemblage include *Turanta barbara* Pessagno and Blome, 1982, *Perispyridium gemmatum* Pessagno and Blome, 1982, *Parvicingula matura* Pessagno and Whalen, 1982, *Zartus jurassicus* Pessagno and Blome, 1980, *Z. imlayi* Pessagno and Blome, 1980, and *Z. thayeri* Pessagno and Blome, 1980.

OR-513.—South Fork Member, Snowshoe Formation near unconformable contact with the overlying Trowbridge Formation. Dark-gray mudstone and graywacke; mudstone with common limestone nodules predominant. Nodules containing well-preserved silicified Radiolaria. U S. G. S. Izee 15′ Quadrangle: T.17S., R.29E., SW ¼ of sect. 7. West side of state highway 63 (Izee–Paulina road) just south of junction of Johnnie Creek with Lewis (Bunton Creek–Duncan Hollow area; same succession as at locs. OR-555 and OR-554).

This horizon lies well above the first occurrence of *Leptosphinctes* Buckman, 1920, in the lowermost part of the South Fork Member (Imlay, 1973, p. 25; Smith, 1980, p. 1607). Furthermore, it occurs considerably above the first occurrence of *Lupherites* Imlay, 1973, which Smith (1980, p. 1607) recorded from the Bunton Creek–Duncan Hollow area, in the lower part of the Schoolhouse Member. Smith (1980) and Westermann and Riccardi (1979, table 2) indicate that *Lupherites* and *Leptosphinctes* first appear at the base of the upper Bajocian (= *rotundum* Zone, Western Hemisphere; = *subfurcatum* Standard Zone and part of overlying *garantiana* Standard Zone, Europe).

The radiolarian assemblage at loc. OR-513 differs from that at locs. OR-549A, OR-549B, OR-549C, and OR-550 (upper Bajocian, Seneca area) by possessing *Turanta officerensis* Pessagno and Blome, 1982, *Zartus imlayi* Pessagno and Blome, 1980, *Pantanellium baileyi* Pessagno and Blome, 1980, *P. malheurense* Pessagno and Blome, 1980, and other elements. The assemblage at loc. OR-513 thus appears to represent a lower horizon in the upper Bajocian.

OR-549A, OR-549B, OR-549C.—Snowshoe Formation (undifferentiated). Predominantly dark-gray mudstone with dark-gray micritic limestone nodules; mudstone with minor, thin-bedded graywacke. U. S. G. S. Seneca 15′ Quadrangle: T.17S., R.31E., SW ¼ of sect. 2; prominent exposure on northeast side of U. S. Highway 395; 1.44 km (0.9 mi) south of Seneca and intersection with Shirttail Creek road; north side of Soda Valley. Locs. OR-549A and OR-549B from mudstones in upper 6.0 m (20 ft) of 76.2 m (250 ft) succession just below massive sandstone on north end of exposure [= U. S. G. S. Mesozoic Localities 29790 and 29792; = Lupher's (1941) loc. 28; see Imlay, 1973]. Loc. OR-549C is situated approximately 21 m (70 ft) below locs. OR-549A and OR-549B. The presence of *Leptosphinctes* Buckman, 1920, and *Megasphaeroceras rotundum* Imlay, 1962b, in the ammonite assemblage at Lupher Locality 28 definitely indicates that this succession is assignable to the upper Bajocian *rotundum* Zone or to its European equivalents (see Westermann and Riccardi, 1979). The radiolarian assemblage at locs.

OR-549A, OR-549B, and OR-549C differs from that at upper Bajocian locality OR-513 by containing *Parvicingula burnsensis* Pessagno and Whalen, 1982, *P. media* Pessagno and Whalen, 1982, *P. grantensis* Pessagno and Whalen, 1982, *Turanta nodosa* Pessagno and Blome, 1982, *T. silviesensis* Pessagno and Blome, 1982, and species of *Pachyonchus* Pessagno and Blome, 1980 (see loc. OR-513 above). There is little question that this represents a younger assemblage that is more closely allied to that at loc. OR-550C (see below).

OR-550C.—Snowshoe Formation (undifferentiated). Predominantly dark-gray mudstone and tuffaceous limestone. Sample from limestone. U. S. G. S. Seneca 15′ Quadrangle: T.17S., R.31E., NE ¼ of sect. 3. Large quarried area on both sides of Shirttail Creek and Shirttail Creek Road. Sample C collected west of creek. Imlay (1973, p. 29) recorded a rich ammonite assemblage at this horizon. He indicated that these strata are definitely of late Bajocian age as shown by the presence of *Spiroceras bifurcatum* (Quenstedt, 1858). This taxon is characteristic of the lower and middle parts of the upper Bajocian (*subfurcatum* to *garantiana* Standard Zones in Europe and Africa; *rotundum* Zone, Western Hemisphere).

The radiolarian assemblage at loc. OR-550C is characterized by the presence of *Parvicingula burnsensis* Pessagno and Whalen, 1982, *P. grantensis* Pessagno and Whalen, 1982, *Perispyridium dumitricai* Pessagno and Blome, 1982, *P. packardi* Pessagno and Blome, 1982, and *Pachyonchus crassus* Pessagno and Blome, 1980. All but the last two taxa also occur lower in the section at locs. OR-549A, OR-549B, and OR-549C. *P. packardi* is also known from the upper Bathonian part of the Snowshoe Formation (locs. OR-501B, OR-501C) and from the middle Callovian part of the Lonesome Formation (loc. OR-530).

OR-501A, OR-501B, OR-501C.—Uppermost part of South Fork Member, Snowshoe Formation. Dark-gray mudstone with common dark-gray, micritic limestone nodules bearing well-preserved, silicified Radiolaria. Samples from separate limestone nodules immediately below the conformable contact with the overlying Trowbridge Formation. U. S. G. S. Izee 15′ Quadrangle: T.17S., R.28E., SE ¼ of sect. 29. Outcrop on north side of state highway 63 (Izee–Paulina road) about 0.65 km (0.4 mi) east of settlement of Izee.

Imlay (1973, pp. D7–D9, locs. 4–7) recovered an ammonite fauna from the upper part of the South Fork Member. He indicated that the ammonites are late Bathonian(?) to early Callovian in age. More recently Imlay (1981, pp. 7–10) assigned the ammonite assemblage from the upper 213 m (700 ft) of the South Fork Member near Izee to the upper Bathonian. For example, at U. S. G. S. Mesozoic Locality 26778, situated about 46 m (150 ft) below the conformable contact with the overlying Trowbridge Formation, Imlay (1973, p. 7) reported *Xenocephalites* Spath, 1928, *Bullatimorphites* Buckman, 1921, *Kepplerites* Neumayr and Uhlig, 1892, *Torricelliceras* Buckman, 1922, *Iniskinites* Imlay, 1975, *Parareineckeia* Imlay, 1962b, *Cobbanites* Imlay, 1962a, and *Choffatia* Siemiradzki, 1898.

The radiolarian assemblage from locs. OR-501A, OR-501B, and OR-501C is characterized by the first occurrences of *Parvicingula blackhornensis* Pessagno and Whalen, 1982, *P. elegans* Pessagno and Whalen, 1982, *P. schoolhousensis* Pessagno and Whalen, 1982, *P. vera* Pessagno and Whalen, 1982, *Ristola* (?) *turpicula* Pessagno and Whalen, 1982, *Perispyridium nitidum* Pessagno and Blome, 1982, *Turanta capsensis* Pessagno and Blome, 1982, and numerous other taxa. Absent are species such as *Perispyridium dumitricai* Pessagno and Blome, 1982, *Parvicingula burnsensis* Pessagno and Whalen, 1982, and *P. grantensis* Pessagno and Whalen, 1982, which are characteristic of the upper Bajocian at loc. OR-550.

OR-530.—Lonesome Formation. Interbedded graywacke and dark-gray, siliceous mudstone bearing small limestone nodules. U. S. G. S. Izee 15′ Quadrangle: T.18S., R.28E., NW ¼ of sect. 3; about 0.16 km (0.1 mi) west of BM 4186 on road between Izee and Burns. North side of road adjacent to South Fork of John Day River on prominent meander bend. Imlay (1981, p. 11) assigned the Lonesome Formation to the upper lower Callovian to Middle Callovian on the basis of the ammonite faunas.

CALIFORNIA COAST RANGES

Lower Jurassic

NSF-958, NSF-959, NSF-960.—From block in melange, Franciscan Complex. Red manganiferous radiolarian ribbon chert overlying pillowed greenstone with minor recrystallized limestone. Contact between basalt and overlying chert seemingly conformable. U. S. G. S. Figueroa Mountain 7.5′ Quadrangle: T.7N., R.29W., sect. 9; 2.1 km (1.32 mi) west of Cachuma Camp (sect. 11), adjacent to Happy Canyon Road. Locs. NSF-958, NSF-959, and NSF-960 are situated 9 m (29 ft), 10 m (34 ft), and 11 m (37 ft) above the contact with pillowed greenstone.

Diagnostic elements in the radiolarian assemblage in these samples include *Canoptum anulatum* Pessagno and Poisson, 1981, *C. rugosum* Pessagno and Poisson, 1981, and *Canutus izeensis* Pessagno and Whalen, 1982. Missing are *Trillus elkhornensis* Pessagno and Blome, 1980, and *Gorgansium morganense* Pessagno and Blome, 1980, which are present in the upper Pliensbachian strata of the Nicely Formation (east-central Oregon) and the Maude Formation (Queen Charlotte Islands, British Columbia). Missing also is *Zartus jurassicus* Pessagno and Blome, 1980, which is known from Toarcian strata (Warm Springs Member, Snowshoe Formation) in east-central Oregon and from probable lower Toarcian strata (Maude Formation) in the Queen Charlotte Islands.

The absence of *T. elkhornensis* and *G. morganense* in this assemblage may indicate that these Franciscan cherts are correlative with either the lowermost part of the *margaritatus* Standard Zone (lowermost upper Pliensbachian) or within the underlying *davoei* Standard Zone (uppermost lower Pliensbachian). In Turkey, Pessagno and Poisson (1981) recorded *Canoptum anulatum* Pessagno and Poisson, 1981, *C. rugosum* Pessagno and Poisson, 1981, and *Praeconocaryomma parvimamma* Pessagno and Poisson, 1981, from the lower member of the Söğütlü dere Formation. Although no megafossils are known from the lower member, the lowermost strata of the upper member include ammonites assignable to the *margaritatus* Standard Zone (lowermost upper Pliensbachian). In the Queen Charlotte Islands, we have not observed these taxa in lower Pliensbachian radiolarian faunas associated with ammonites assignable to the *ibex* Standard Zone.

Upper Jurassic

NSF-906, NSF-907, NSF-908, NSF-909.—Volcanogenic-pelagic strata overlying the Coast Range ophiolite at Point Sal, Santa Barbara County, California. Green to black, thin-bedded tuffaceous chert with nodules and lenses of light-gray, micritic limestone. U. S. G. S. Point Sal 7.5′ Quadrangle: T.10N., R.36W., near western margin of sect. 34.

NSF-906.—Green tuffaceous, radiolarian chert. 10.6 m (35 ft) above contact with ophiolite. Lower Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984); below first occurrence of *Parvicingula* Pessagno *s. s.*; upper Kimmeridgian (*sensu gallico*).

NSF-907.—Lens of light-gray, micritic, tuffaceous limestone about 0.45 m (1.5 ft) thick. 11.5 m (38 ft) above contact with ophiolite. Upper Zone 2; above first occurrence of *Parvicingula* Pessagno *s. s.*; upper Kimmeridgian (*sensu gallico*).

NSF-908.—Small, light-gray, micritic limestone nodules. 13.4 m (44 ft) above contact with ophiolite. Lower Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984); lower Tithonian (*sensu gallico*).

NSF-909. Small, greenish-gray, micritic limestone nodule. 15.8 m (52 ft) above contact with ophiolite.

SA-108, SA-109, SA-111*.—Unnamed lithostratigraphic unit above Coast Range ophiolite and below Great Valley sequence *sensu stricto*. Light- to medium-gray mudstone resting unconformably above the ophiolite breccia at the top of the ophiolite and conformably below the Great Valley sequence. Blocks of ophiolite breccia derived from the underlying ophiolite are included in the mudstone. In addition, Hopson, Mattinson, and Pessagno (1981) indicated that several beds of dark ophiolitic microbreccia are interbedded with the mudstone. Red radiolarian cherts occurring below the ophiolite breccia unit contain a radiolarian assemblage with "*Eucyrtidium*" *ptyctum* Riedel and Sanfilippo, 1974, *Acanthocircus variabilis* (Squinabol, 1914), and *Ristola* sp. aff. *R. decora* Pessagno and Whalen, 1982. This assemblage is assignable to the upper part of Zone 1 (*sensu* Pessagno, Blome, and Longoria, 1984) and is either late Callovian or early Oxfordian in age. U. S. G. S. Paskenta 7.5′ Quadrangle: T.23N., R.7W.; sect. 2; near Crowfoot Point.

SA-108.—Laminated, medium-gray mudstone with abundant Radiolaria. 63.7 m (209 ft) above contact with ophiolite breccia. Upper Zone 2; upper Kimmeridgian (*sensu gallico*).

SA-109.—Laminated, medium-gray mudstone with abundant Radiolaria. 60 m (197 ft) above contact with ophiolite breccia unit. Upper Zone 2; upper Kimmeridgian (*sensu gallico*).

SA-111.—Laminated, medium-gray mudstone with abundant Radiolaria. 44.5 m (146 ft) above contact with ophiolite breccia unit. Upper Zone 2; upper Kimmeridgian (*sensu gallico*).

JP-1.—Same unit as SA-108–111 (see above). Light-gray mudstone with abundant Radiolaria. U. S. G. S. Paskenta 7.5′ Quadrangle: T.23N., R.7W., sect. 2 near Crowfoot Point. Upper Zone 2; upper Kimmeridgian (*sensu gallico*). Sample collected by Dr. D. L. Jones (U. S. Geol. Survey, Menlo Park, CA). Jones (1975, p. 330) found *Buchia rugosa* (Fischer, 1830–1837) and specimens transitional between *B. rugosa* and *B. concentrica* (Sowerby, 1827) in samples from this horizon. The horizon of concurrence between *B. concentrica* and *B. rugosa* is correlative with the *eudoxus* Standard Zone and the underlying *mutabilis* Standard Zone (upper Kimmeridgian, northwestern Europe) and with the *eudoxus* and *acanthicum* Standard Zones (upper Kimmeridgian, European Tethys) (see discussion in Pessagno, Blome, and Longoria, 1984).

QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA

Lower Jurassic

QC-675.—Black argillite member, Kunga Formation. 374.3 m (1227.8 ft) above contact with middle black limestone member. Type locality of Kunga Formation; north shore of Kunga Island. Thin-bedded, dark-gray argillite with dark-gray, micritic limestone nodules containing well-preserved, silicified Radiolaria. Ammonites from below this horizon are assignable to the *raricostatum* Standard Zone of the uppermost Sinemurian.

QC-590A.—Black argillite member, Kunga Formation. Type locality of Kunga Formation; north shore of Kunga Island. Thin-bedded, dark-gray argillite with dark-gray, micritic limestone nodules containing well-preserved, silicified Radiolaria. 386.4 m (1267.5 ft) above contact with middle black limestone member. Upper Sinemurian; *raricostatum* Standard Zone.

QC-676.—Black argillite member, Kunga Formation. Type locality of Kunga Formation; north shore of Kunga Island. Thin-bedded, dark-gray argillite with dark-gray, micritic limestone nodules containing well-preserved, silicified Radiolaria. 407.9 m (1337.8 ft) above contact with middle black limestone member. Upper Sinemurian; *raricostatum* Standard Zone.

QC-532.—Maude Formation. Type locality of Maude Formation at Maude Island. Dark-gray siliceous mudstone, siltstone, lithic sandstone, and micritic limestone. Sample from loc. QC-532 from dark-gray, micritic limestone 21 to 26 cm (8 to 10 in) thick; abundant, well-preserved, silicified Radiolaria. 79.4 m (269.5 ft) above base of Maude Formation.

The radiolarian assemblage at this locality differs somewhat from that at locs. QC-534 and QC-537. However, its early Pliensbachian age can be established by its relation to underlying and overlying strata that contain early Pliensbachian ammonites (see Sutherland Brown, 1968, pp. 436–456 and data from localities QC-535 and QC-537 herein). Lower Pliensbachian; *ibex* Standard Zone.

QC-534.—Maude Formation. Type locality at Maude Island. Dark-gray, micritic limestone bed 26 cm (10 in) thick with abundant, well-preserved, silicified Radiolaria. 83.6 m (274.5 ft) above base of Maude Formation. The proximity of this locality to loc. QC-535 (see below) and the close similarity of the radiolarian assemblage to that at loc. QC-537 suggest that loc. QC-534 is of early Pliensbachian age.

QC-535.—Maude Formation. Type locality at Maude Island. Lenticular mass of dark-gray, silty, micritic limestone. 86.1 m (282.5 ft) above base of Maude Formation.

An ammonite collected from this locality was identified by Dr. Ralph W. Imlay (U. S. Geological Survey, Washington, DC; report on referred fossils, Sept. 1977) as *Tropidoceras actaeon* (d'Orbigny, 1844). Frebold (1970, p. 445) indicated that this taxon is one of the "guide fossils" for the *ibex* Standard Zone (lower Pliensbachian).

QC-537.—Maude Formation. Type locality at Maude Island. 15 cm (6 in) bed of medium-gray, micritic limestone with abundant, well-preserved, silicified Radiolaria. 90.7 m (297.5 ft) above base of Maude Formation; 0.9 m (3 ft) below a horizon with coarse tuffaceous sandstone.

Three ammonites from this locality were submitted to Dr. Ralph W. Imlay (U. S. Geological Survey, Washington, DC). Imlay (report on referred fossils, Sept. 1977) identified these as *Uptonia* sp. and *Uptonia* sp. cf. *U. dayiceroides* Mouterde, 1951. In the Queen Charlotte Islands *U.* sp. cf. *U. dayiceroides* Mouterde appears to be restricted to the *ibex* Standard Zone (Frebold, 1970, p. 445).

QC-622.—Maude Formation. South shore of Skitegate Inlet opposite Maude Island. Light-gray, micritic limestone with abundant, well-preserved, silicified Radiolaria. 38.2 m (125.5 ft) above the base of the Maude. This horizon lies 12.3 m (40.5 ft) above the occurrence of lower Pliensbachian ammonites assignable to the *ibex* Standard Zone and 44 m (144.5 ft) below the occurrence of lower Toarcian ammonites assignable to the *falcifer* Standard Zone (see Pessagno and Whalen, 1982, p. 162).

The radiolarian assemblage present at this horizon appears to be indicative of the upper Pliensbachian. Significantly, it possesses *Gorgansium morganense* Pessagno and Blome, 1980, and *Trillus elkhornensis* Pessagno and Blome, 1980, which both make their first appearance in the upper Pliensbachian Nicely Formation of east-central Oregon (loc. OR-536). It lacks *Zartus jurassicus* Pessagno and Blome, 1980, which is present in the Maude Formation (south shore of Skidegate Inlet) at loc. QC-624, 27.4 m (90 ft) below the occurrence of lower Toarcian ammonites assignable to the *falcifer* Standard Zone (see Pessagno and Whalen, 1982, p. 162). In east-central Oregon *Zartus jurassicus* is present in upper Toarcian strata at loc. OR-589 and is profusely abundant in Aalenian(?) and lower Bajocian strata.

* The strata at this locality are steeply overturned.

VIZCAINO PENINSULA, BAJA CALIFORNIA SUR

Lower Jurassic

SH-412-14.—Sandstone member (lower third) of San Hipólito Formation. Thin- to medium-bedded, poorly-sorted, olive-gray to light-greenish-brown, tuffaceous sandstone interbedded with silty and cherty tuffs and silty, tuffaceous, light-gray limestone. Sample from light-gray, micritic limestone nodule containing well-preserved Radiolaria. Approximately 250 m (820 ft) above the base of the sandstone member. Punta San Hipólito; type locality of the San Hipólito Formation. Upper Pliensbachian; ?Toarcian. Sample from Dr. David Barnes (SOHIO, Dallas, TX).

BPW-14.—Sandstone member (lower third) of San Hipólito Formation. Lithology same as for SH-412-14 (above). Sample from light-gray, micritic limestone nodule with well-preserved, silicified Radiolaria. 261.2 m (856.7 ft) above the base of the sandstone member. Punta San Hipólito; type locality of San Hipólito Formation. Upper Pliensbachian; ?Toarcian.

BPW-28.—Sandstone member (lower third) of San Hipólito Formation. Lithology same as for SH-412-14 (above). Sample from a tan, micritic limestone bed 6.3 cm (2.5 in) thick. 303.1 m (994.2 ft) above the base of the sandstone member. Punta San Hipólito; type locality of San Hipólito Formation. Upper Pliensbachian; ?Toarcian.

BPW-30*.—Sandstone member (lower third) of San Hipólito Formation. Lithology same as for SH-412-14 (above). Sample a medium-gray, slightly silty, micritic limestone bed 5 cm (2 in) thick. Approximately 345 m (1131.6 ft) above base of sandstone member. Punta San Hipólito; type locality of the San Hipólito Formation. Upper Pliensbachian; ?Toarcian.

TAMAN–TAMAZUNCHALE AREA, SAN LUIS POTOSÍ, EAST-CENTRAL MEXICO

Upper Jurassic

MX-80-20.—Middle portion of lower, more massively-bedded part of Taman Formation. Medium-bedded, dark-gray, micritic limestone with ammonites, abundant *Aulacomyella* Furlani, 1910, and abundant calcified Radiolaria. 0.1 km (0.06 mi) west of kilometer post km 265 on Route 85 (Mexico, D.F.—Nuevo Laredo highway). An ammonite submitted to Dr. Ralph W. Imlay (U. S. Geological Survey, Washington, DC; report on referred fossils, Nov. 1980) was said to greatly resemble *Subneumayria profulgens* (Burckhardt, 1906) of "middle Kimmeridgian" age. Imlay noted, however, that this ammonite was too poorly preserved for definite identification. Loc. MX-80-20 is also situated 1.9 km (1.1 mi) east-northeast of La Cuesta, where Burckhardt (*in* Heim, 1926) noted *Aulacomyella* Furlani, 1910, and *Glochiceras fialar* (Oppel, 1858) (= upper Kimmeridgian *sensu gallico*).

MX-82-3.—Middle portion of lower, more massively-bedded part of Taman Formation. Platy, thin-bedded, dark-gray, micritic limestone with medium-bedded, dark-gray, micritic limestone. Sample containing well-preserved, silicified Radiolaria from platy, thin-bedded limestone. Above the first occurrence of *Aulacomyella* Furlani, 1910, in the Taman Formation. Just west of km 266 on Route 85 (Mexico, D.F.—Nuevo Laredo highway). This horizon lies below the first appearance of *Mirifusus* Pessagno, 1977a, at loc. MX-82-8 and hence, is tentatively assigned to uppermost Zone 1 (*sensu* Pessagno, Blome, and Longoria, 1984). The presence of *Aulacomyella* at somewhat lower stratigraphic horizons indicates that the strata at loc. MX-82-3 are no older than the *Idoceras* Zone of Cantu Chapa (1971) (= latest early Kimmeridgian). In Mexico, *Aulacomyella* ranges from the *Idoceras* Zone to the *Virgatosphinctes mexicanus–Aulacomyella neogeae* Zone of Cantu Chapa (1971) (lower Kimmeridgian to upper Tithonian [see p. 19]). In conclusion, strata at loc. MX-82-3 may either be correlative with the *Idoceras* Zone (uppermost lower Kimmeridgian) or with the *Glochiceras* gp. *fialar* Zone (upper Kimmeridgian). The radiolarian assemblage still lacks *Parvicingula* Pessagno *s. s.* (forms with tubular structure on final post-abdominal chamber). In California *Parvicingula s. s.* first appears in upper Kimmeridgian strata assignable to the upper part of Zone 2 (Locs. JP-1, SA-108, SA-109, NSF-907).

MX-82-6.—Middle portion of lower, more massively-bedded part of Taman Formation. Thin-bedded, reddish-weathering, dark-gray, micritic limestone interbedded with medium-bedded, dark-gray, micritic limestone. Sample from thin-bedded limestone containing well-preserved silicified Radiolaria. Above loc. MX-82-3 and below loc. MX-82-8 in section. Approximately 45 m (150 ft) west of km 266 on Route 85 (Mexico, D.F.—Nuevo Laredo highway); about 6 km (3.7 mi) east of village of Taman. Upper part of Zone 1 (?). Below first occurrence of *Mirifusus* Pessagno, 1977a. Upper part of lower Kimmeridgian *Idoceras* Zone of Cantu Chapa, 1971?; probably lower part of upper Kimmeridgian (*Glochiceras* gp. *fialar* Zone of Cantu Chapa, 1971).

MX-82-8.—Middle portion of lower, more massively-bedded part of Taman Formation. Predominantly medium-bedded, dark-gray micritic limestone with occasional thin beds (10.2 cm [4 in] to 20.3 cm [8 in]). Samples bearing well-preserved, silicified Radiolaria from adjacent 10.2 cm and 20.3 cm beds. Adjacent to and slightly east of km 266 on Route 85 (Mexico, D.F.—Nuevo Laredo highway); 6 km east-northeast of village of Taman. First apparent occurrence of *Mirifusus* Pessagno, 1977a. Apparent base of Zone 2. Upper part of lower Kimmeridgian (*Idoceras* Zone; Cantu Chapa, 1971) or lower part of upper Kimmeridgian (*Glochiceras* gp. *fialar* Zone; Cantu Chapa, 1971). Probably upper Kimmeridgian. Below first occurrence of *Parvicingula* Pessagno *s. s.* (upper part of Zone 2; upper Kimmeridgian).

MX-82-15.—Upper part of lower, more massively-bedded portion of Taman Formation. Dark-gray, medium-bedded, micritic limestone with interbedded shale containing limestone nodules. Indeterminate ammonites, *Aulacomyella* sp., and well-preserved Radiolaria occur in limestone nodules. Radiolaria replaced by pyrite and limonite. Above first occurrence of *Parvicingula* Pessagno *s. s.* (forms with post-abdominal tubes). Upper Zone 2; upper Kimmeridgian. Route 85 (Mexico, D.F.—Nuevo Laredo highway); just east of km 267 and west of major turn in road.

MX-82-16.—Upper part of lower, more massively-bedded part of Taman Formation. Dark-gray micritic, medium-bedded limestone with interbedded shale containing limestone nodules with silicified Radiolaria. Same horizon as loc. MX-82-15. Route 85 (Mexico, D.F.—Nuevo Laredo highway); east of km 267 and east of major turn in road. Upper Zone 2; upper Kimmeridgian (*sensu gallico*).

MX-82-17.—Upper part of lower, more massively-bedded part of Taman Formation. Dark-gray, medium-bedded, micritic limestone with interbedded shale containing limestone nodules. Limestone nodules with well-preserved, pyritized Radiolaria. Route 85 (Mexico, D.F.—Nuevo Laredo highway); west of km 268 and about 0.8 km (0.5 mi) west of hanging bridge over Río Moctezuma at Village of La Vega (= La Vega Larga of some maps). Zone 3; lower Tithonian. Within the *Virgatosphinctes mexicanus–Aulacomyella*

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* The presence of *Canoptum anulatum* Pessagno and Poisson, 1981, *Gorgansium morganense* Pessagno and Blome, 1980, and *Trillus elkhornensis* Pessagno and Blome, 1980, in the radiolarian assemblage from this locality and the other localities cited above suggests that these strata are no older than late Pliensbachian. The absence of *Zartus jurassicus* Pessagno and Blome, 1980, probably indicates a late Pliensbachian rather than a Toarcian age.

neogeae Zone of Cantu Chapa (1971). Overlying strata of lower, more massively-bedded Taman still with *Aulacomyella* Furlani, 1910.

MX-81-54.—Upper part of lower, more massively-bedded part of Taman Formation. Dark-gray, micritic, medium-bedded limestone with interbedded shale containing limestone nodules. Sample from small limestone nodule with well-preserved, pyritized Radiolaria. Route 85 (Mexico, D.F.—Nuevo Laredo highway) west of km 268; 0.77 km (0.48 mi) west of hanging bridge over Río Moctezuma at village of La Vega (= La Vega Larga of some maps), 0.48 km west of km 268. Zone 3; lower Tithonian. Close to final occurrence of *Aulacomyella* and top of *Virgatosphinctes mexicanus–Aulacomyella neogeae* Zone of Cantu Chapa (1971).

MX-82-19.—Upper part of lower, more massively-bedded part of Taman Formation. Dark-gray, medium-bedded, micritic limestone with interbedded shale. Shale and limestone both containing limestone nodules. Sample a large, dark-gray, micritic limestone nodule from platy limestone layer about 30.4 cm (1 ft) thick; containing well-preserved pyritized Radiolaria. 20 m (65.5 ft) below the first occurrence of hyaline calpionellids (= base of upper Tithonian; *sensu* Pessagno, Blome, and Longoria, 1984). Route 85 (Mexico, D.F.—Nuevo Laredo highway) west of km 268; 0.76 km (0.45 mi) west of hanging bridge over Río Moctezuma at village of La Vega (= La Vega Larga of some maps). Zone 3; lower Tithonian; upper part. Upper part of *Virgatosphinctes mexicanus–Aulacomyella neogeae* Zone of Cantu Chapa (1971).

MX-82-20.—Upper part of lower, more massively-bedded part of Taman Formation. Dark-gray, medium-bedded, micritic limestone with interbedded shale containing limestone nodules. Limestone nodules with well-preserved, pyritized Radiolaria. 10 m (32.8 ft) above loc. MX-82-19; 10 m (32.8 ft) below the first occurrence of hyaline calpionellids in the lower, massively-bedded part of Taman Formation. Route 85 (Mexico, D.F.—Nuevo Laredo highway). Zone 3 (upper part); lower Tithonian. Upper part of *Virgatosphinctes mexicanus–Aulacomyella neogeae* Zone of Cantu Chapa (1971). *Aulacomyella neogeae* Imlay, 1940, occurs in the lower Taman just below its contact with the upper Taman near km 268. It also has been observed in the lower part of the upper Taman (see loc. MX-85-35 below).

MX-85-35.—Lower part of thin-bedded upper Taman (= lower Pimienta of Cantu Chapa, 1971; see Pessagno, Longoria, MacLeod, and Six, *in press*). Thin-bedded, black to dark-gray micritic limestone with thin beds of yellowish-weathering shale containing large limestone nodules. 30 m (96.8 ft) above contact with massively-bedded lower Taman. Immediately north of new highway bridge over Río Moctezuma connecting Taman (San Luis Potosí) on south side of river with Barrio de Guadalupe (San Luis Potosí) on north side of river. Exposure on east side of Barrio de Guadalupe along new road. East limb of tightly-folded synclinal structure, which is overturned to the east. 20 cm (8 in) dark-gray, micritic limestone nodule containing *Aulacomyella neogeae* Imlay, 1940, and *Salinites grossicostatum* (Imlay, 1939). Radiolaria assignable to the lower part of Zone 4 (*sensu* Pessagno, Blome, and Longoria, 1984) occur above and below this horizon. This succession is discussed in more detail by Pessagno, Longoria, MacLeod, and Six, *in press*).

MX-82-37.—Middle portion of thin-bedded, upper part of Taman Formation (= lower Pimienta of Cantu Chapa, 1971). Thin-bedded, black to dark-gray micritic limestone with thick beds of black, yellowish-weathering shale containing abundant, black, micritic, fist-sized limestone nodules with well-preserved Radiolaria. Upper Taman strata occurring in axial zone of tight synclinal fold noted at loc. MX-85-35 above. About 72 m (239 ft) above loc. MX-85-35 (see above). 0.94 km (0.6 mi) from new highway bridge over Río Moctezuma on road above Barrio de Guadalupe (San Luis Potosí).

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* For exact dates of publication, see Imlay, 1964b, p. B55.
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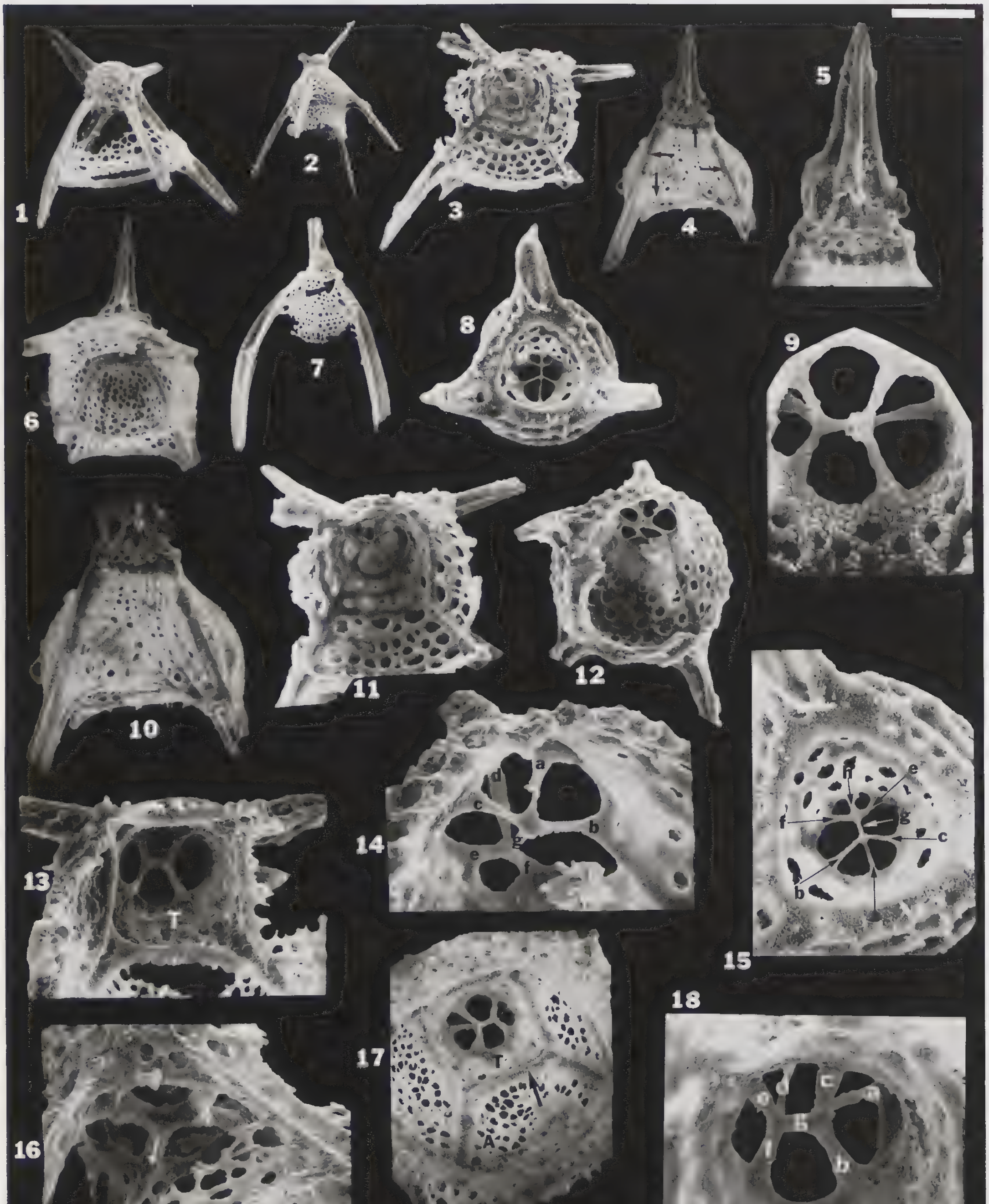
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EXPLANATION OF PLATE 1

All figures are scanning electron micrographs of Jurassic Nassellariina from the Suplee–Izee area, Grant County, east-central Oregon. Scale bar (upper right) is used as a reference for the magnification of all figures. **a** = vertical bar; **b** = primary left lateral bar; **c** = primary right lateral bar; **d** = apical bar; **e** = secondary right lateral bar; **f** = secondary left lateral bar; **g** = median bar; **h** = dorsal bar; **T** = thorax; **A** = abdomen.

Figure — Page

1, 16. ***Rolumbus*** species 21
Lower part of Hyde Formation. loc. OR-600. Lower Jurassic (upper Pliensbachian?; lower Toarcian; upper Toarcian?).
1. Scale bar = 61.2 μm.
16. Illustration at higher magnification; showing primary and secondary lateral bars each connected directly with infacing ridge of a given foot (white arrow). We have not observed this relationship on other specimens of *Rolumbus,* n. gen., or *Farcus,* n. gen. However, specimens of *Rolumbus* and *Farcus* (figs. 11, 12) do show a definite alignment of the four lateral elements with the feet. In this case, there is no direct structural connection between the lateral elements and the feet. Scale bar = 14.1 μm.

2. ***Rolumbus*** species 26
Warm Springs Member, Snowshoe Formation. loc. OR-589. Lower Jurassic (upper Toarcian). Note tubular velum-like structure extending from base of thorax. Scale bar = 150 μm.

3, 11, 18. ***Rolumbus*** species 23
Warm Springs Member, Snowshoe formation. loc. OR-589. Lower Jurassic (upper Toarcian). Note alignment of four feet with primary and secondary lateral elements. Figure 18 shows cephalic skeletal elements. Terminology follows that of Goll (1968, p. 1413) and Pessagno (1969, pl. 24). Note that the dorsal bar is absent; compare with figures 15 and 17. Collar pores blackened in figure 18 to increase contrast. Scale bar = 59, 37.5, and 15 μm, respectively.

4, 5, 6, 10. unnamed hilarisiregid with single horn 29, 30
Upper part of South Fork Member, Snowshoe Formation. loc. OR-501B. Middle Jurassic (upper Bathonian). Arrows (fig. 4) point to one of four A-frames. Figure 6 shows circular aperture bordered by an imperforate rim; area between rim and base of A-frame comprised of latticed meshwork. Note two layers of abdomen (fig. 10); outer latticed layer formed of vermicular ridges. Scale bar = 84, 39, 75, and 54 μm, respectively.

7. unnamed dicyrtid nassellarian (ultranaporid?) with two feet 32
South Fork Member, Snowshoe Formation. loc. OR-501B. Middle Jurassic (upper Bathonian). Arrow points to cephalocone. Scale bar = 120 μm.

8, 15. ***Napora*** species 32
South Fork Member, Snowshoe Formation. loc. OR-501B. Middle Jurassic (upper Bathonian). Note that the pore frames inside of the test are flattened and low in relief whereas those on the outside of test are high in relief. Figure 15 shows cephalic skeletal elements. A dorsal bar is present among species of *Napora* Pessagno, 1977a. However, it is lacking with species of *Hilarisirex* Takemura and Nakaseko, 1982, *Farcus,* n. gen., and *Rolumbus,* n. gen. Apical bar not shown in this view. Scale bar = 60 and 30 μm, respectively.

9. ***Hilarisirex*** species 30
South Fork Member, Snowshoe Formation. loc. OR-501B. Middle Jurassic (upper Bathonian). Note absence of dorsal bar among cephalic skeletal elements. Scale bar = 39 μm.

12, 14. ***Farcus*** species 23
Lower part of Hyde Formation. loc. OR-600. Lower Jurassic (upper Pliensbachian?; lower Toarcian; upper Toarcian?). Figure 14 shows cephalic skeletal elements. Note absence of dorsal bar. Scale bar = 40 and 15 μm, respectively.

13. ***Hilarisirex*** species 30
South Fork Member, Snowshoe Formation. loc. OR-501B. Middle Jurassic (upper Bathonian). Note thorax (T) and absence of dorsal bar among cephalic skeletal elements. Scale bar = 30 μm.

17. ***Hilarisirex inflatus,*** new species 30
Topotype. South Fork Member, Snowshoe Formation. loc. OR-501B. Middle Jurassic (upper Bathonian). Arrow points to imperforate shelflike partition separating thorax from abdomen at top of A-frames. Circular aperture (mouth) at base of abdomen is like that described in figure 6. Scale bar = 37.5 μm.

EXPLANATION OF PLATE 2

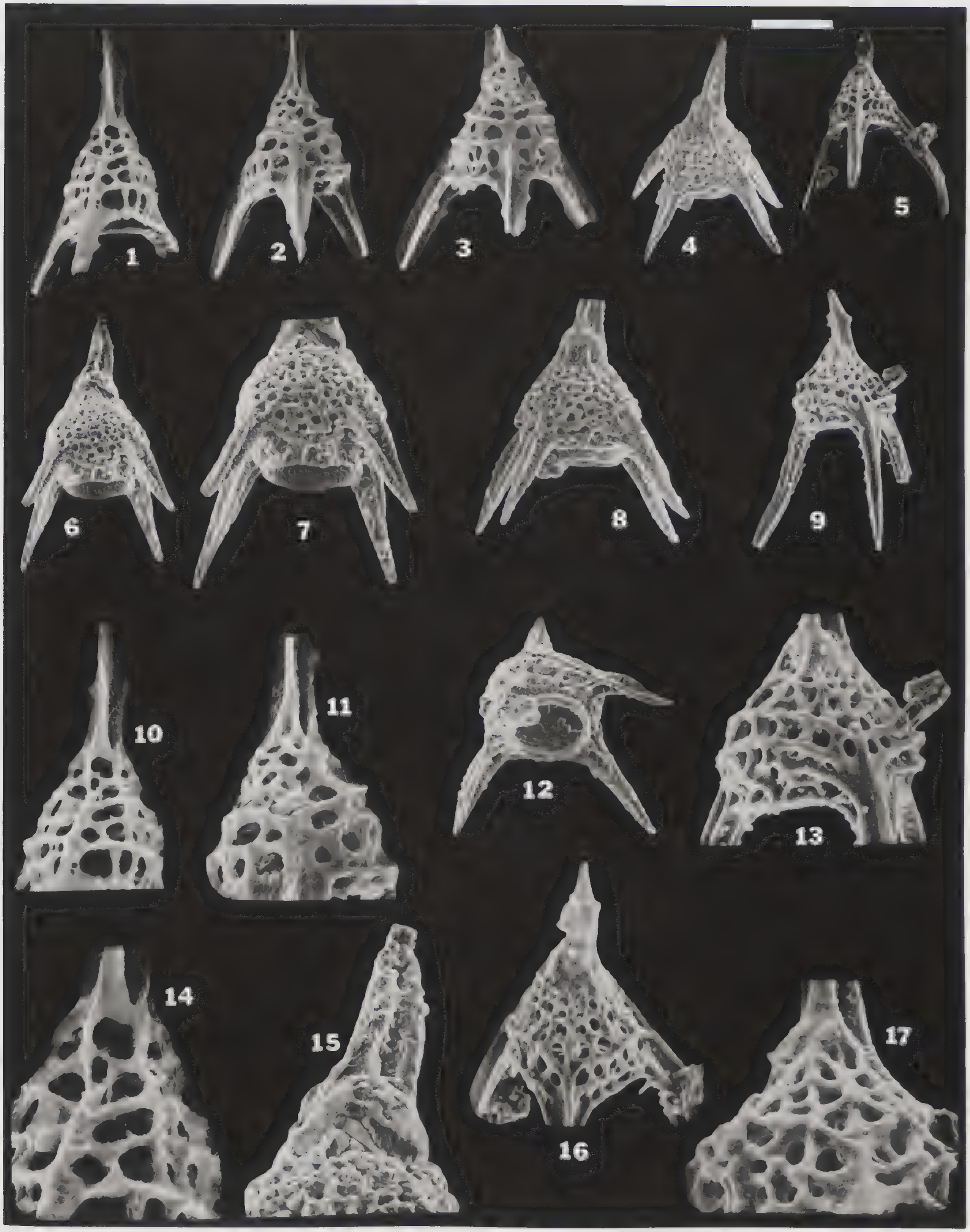
All figures are scanning electron micrographs of ultranaporid and farcid Nassellariina from the Lower Jurassic Kunga and Maude formations, Queen Charlotte Islands, British Columbia; and the Nicely Formation, east-central Oregon. Scale bar (upper right) is used as a reference for the magnification of all figures.

Figure — Page

1–3, 10, 11, 14. ***Napora*** (?) ***graybayensis***, new species 39
Black argillite member, Kunga Formation, Queen Charlotte Islands.
1, 10, 14. Holotype (USNM 379327). loc. QC-675; upper Sinemurian. Scale bar = 48, 30, and 38 μm, respectively.
2, 11. Paratypes (Pessagno Collection). loc. QC-675; upper Sinemurian. Scale bar = 58.8 and 30 μm, respectively.
3. Paratype (Pessagno Collection). loc. QC-675; upper Sinemurian. Scale bar = 54 μm.

4, 6–8, 12, 15. ***Farcus graylockensis***, new species 24
Nicely Formation, east-central Oregon.
6, 7, 15. Holotype (USNM 379278). loc. OR-536; upper Pliensbachian. Scale bar = 84 and 150 μm.
4, 8, 12. Paratype (Pessagno Collection). loc. OR-536; upper Pliensbachian. Scale bar = 99, 75, and 75 μm, respectively.

5, 9, 13, 16, 17. ***Jacus*** (?) ***sandspitensis***, new species 33
Maude Formation, Queen Charlotte Islands.
5, 16, 17. Paratype (Pessagno Collection). loc. QC-534; lower Pliensbachian. Scale bar = 120, 60, and 30 μm, respectively.
9, 13. Holotype (USNM 379294). loc. QC-534; lower Pliensbachian. Scale bar = 99 and 60 μm, respectively.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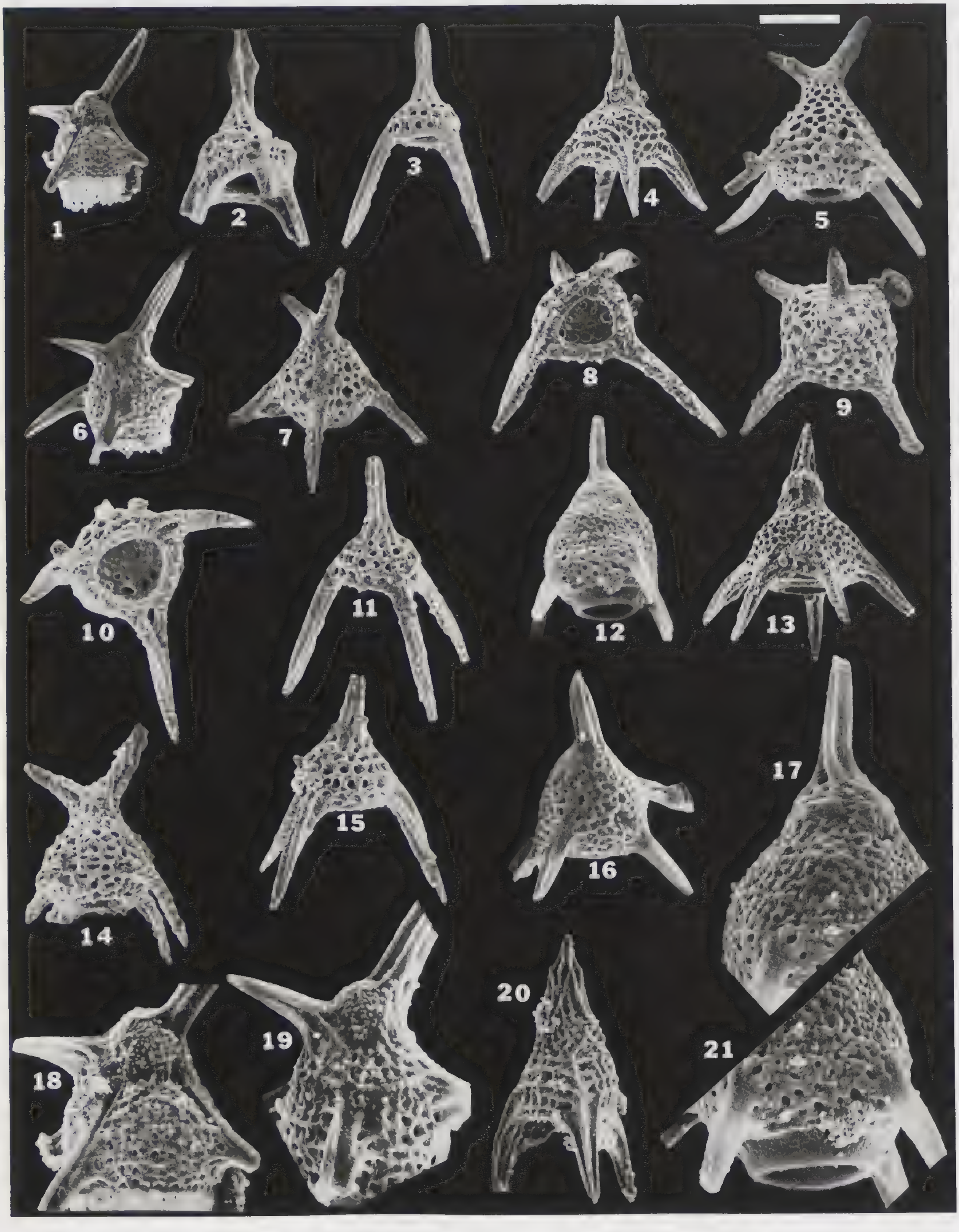
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EXPLANATION OF PLATE 3

All figures are scanning electron micrographs of farcid and ultranaporid Nassellariina from the Lower Jurassic San Hipólito Formation, Vizcaino Peninsula, Baja California Sur, Mexico; the Franciscan Complex, California; and the Nicely Formation, east-central Oregon. Scale bar (upper right) is used for the magnification of all figures.

Figure — Page

1, 6, 18, 19. ***Rolumbus halseyensis***, new species 28
Sandstone member, San Hipólito Formation.
1, 18. Holotype (USNM 379353). loc. SH-412-14; upper Pliensbachian; ?Toarcian. Scale bar = 88.2 and 42.8 μm, respectively.
6, 19. Paratype (Pessagno Collection). loc. SH-412-14; upper Pliensbachian; ?Toarcian. Scale bar = 83.7 and 46.5 μm, respectively.

2. ***Jacus*** (?) species aff. ***J.*** (?) ***sandspitensis***, new species 33
Red ribbon cherts, Franciscan Complex. loc. NSF-960; lower Pliensbachian?; upper Pliensbachian. Scale bar = 84 μm.

3, 8, 10, 11, 15. ***Napora morganensis***, new species 43
Nicely Formation. Upper Pliensbachian.
3, 8, 11. Holotype (USNM 379343). loc. OR-536. Scale bar = 120, 84, and 99 μm, respectively.
10, 15. Paratype (Pessagno Collection). loc. OR-536. Scale bar = 84 and 99 μm, respectively.

4. ***Farcus*** species A 24
Nicely Formation. loc. OR-536; upper Pliensbachian. Scale bar = 107 μm.

5, 7, 9, 14. ***Rolumbus hamiltoni***, new species 26
Nicely Formation.
5. Holotype (USNM 379282). loc. OR-536; upper Pliensbachian. Scale bar = 99 μm.
7, 9, 11. Paratypes (Pessagno Collection). loc. OR-536; upper Pliensbachian. Scale bar = 99, 120, and 84 μm, respectively.

12, 16, 17, 21. ***Farcus asperoensis***, new species 23
Sandstone member, San Hipólito Formation.
12, 17, 21. Holotype (USNM 379276). loc. SH-412-14; upper Pliensbachian; ?Toarcian. Scale bar = 61.2, 30, and 31.6 μm, respectively.
16. Paratype (Pessagno Collection). loc. SH-412-14; upper Pliensbachian; ?Toarcian. Scale bar = 72 μm.

13. ***Farcus*** species B 24
Nicely Formation. loc. OR-536; upper Pliensbachian. Scale bar = 85.5 μm.

20. ***Jacus*** (?) species C 34
Sandstone member, San Hipólito Formation. loc. SH-412-14; upper Pliensbachian; ?Toarcian. Scale bar = 61.2 μm.

EXPLANATION OF PLATE 4

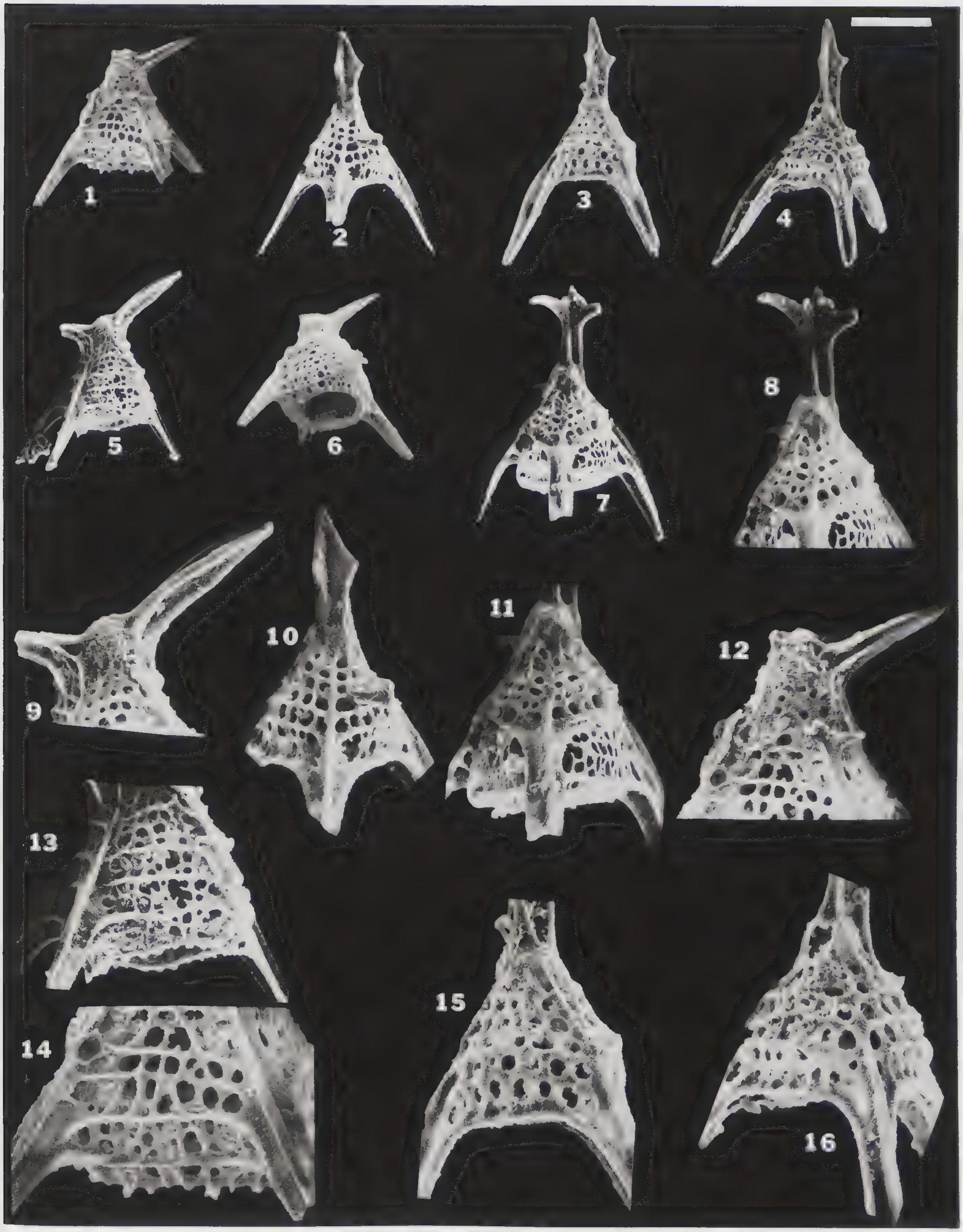
All figures are scanning electron micrographs of farcid and ultranaporid Nassellariina from the Lower Jurassic part of the San Hipólito Formation, Vizcaino Peninsula, Baja California Sur, Mexico. Scale bar (upper right) is used as a reference for the magnification of all figures.

Figure — Page

1, 5, 6, 9, 12–14. ***Rolumbus gastili***, new species 26
Sandstone member, San Hipólito Formation.
1, 6, 12, 14. Paratype (Pessagno Collection). loc. BPW-30; upper Pliensbachian; ?Toarcian. Scale bar = 88.2, 88.2, 40, and 30 μm, respectively.
5, 9, 13. Holotype (USNM 379280). loc. BPW-30; upper Pliensbachian; ?Toarcian. Scale bar = 88.2, 40, and 40 μm, respectively.

2–4, 10, 15, 16. ***Napora cerromesaensis***, new species 38
Sandstone member, San Hipólito Formation.
2, 10. Holotype (USNM 379321). loc. BPW-30; upper Pliensbachian; ?Toarcian. Scale bar = 88.5 and 54 μm, respectively.
3, 15; 4, 16. Paratypes (Pessagno Collection). loc. BPW-30; upper Pliensbachian; ?Toarcian. Scale bar = 88.2, 40 μm; 87, 40 μm, respectively.

7, 8, 11. ***Jacus reiferensis***, new species 32
Holotype (USMN 379292). Sandstone member, San Hipólito Formation. loc. BPW-30; upper Pliensbachian; ?Toarcian. Scale bar = 81, 54, and 51 μm, respectively.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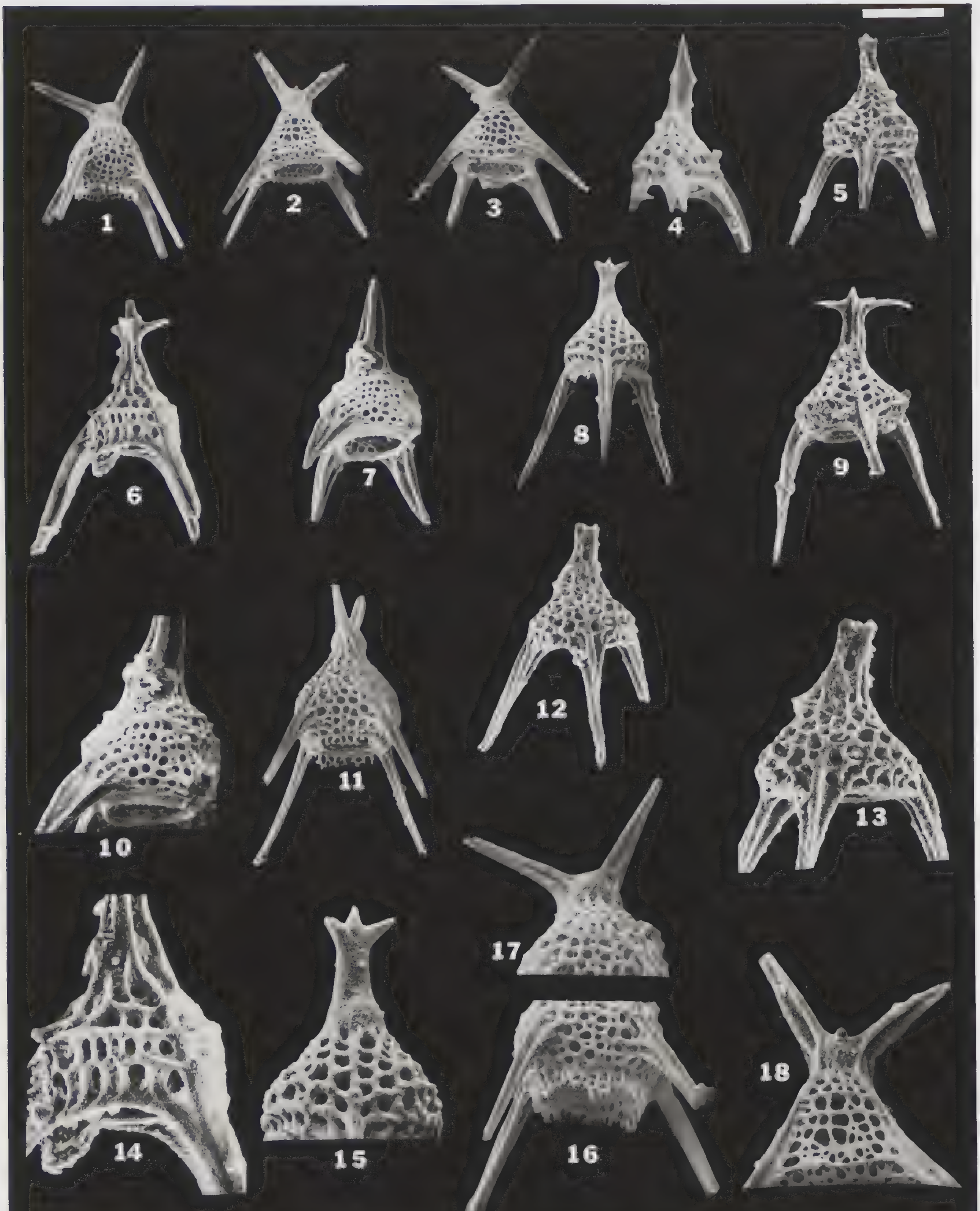
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EXPLANATION OF PLATE 5

All figures are scanning electron micrographs of ultranaporid and farcid Nassellariina from the Lower Jurassic: Maude Formation, Queen Charlotte Islands, British Columbia; Hyde and Snowshoe formations, Grant County, east-central Oregon; and San Hipólito Formation, Vizcaino Peninsula, Baja California Sur, Mexico. Scale bar (upper right) is used as a reference for the magnification of all figures.

Figure — Page

1, 11, 16, 17. ***Rolumbus mirus***, new species 28

1, 16, 17. Holotype (USNM 379284). Hyde Formation. loc. OR-600; upper Pliensbachian?; lower Toarcian; ?upper Toarcian. Scale bar = 120, 60, and 60 μm, respectively.

11. Paratype (Pessagno Collection). Hyde Formation. loc. OR-600; upper Pliensbachian?; lower Toarcian; ?upper Toarcian. Scale bar = 84 μm.

2, 3, 18. ***Rolumbus venustus***, new species 32

2, 18. Holotype (USNM 379286). Hyde Formation. loc. OR-600; upper Pliensbachian?; lower Toarcian; ?upper Toarcian. Scale bar = 99 and 60 μm, respectively.

3. Paratype (Pessagno Collection). Hyde Formation. loc. OR-600; upper Pliensbachian?; lower Toarcian; ?upper Toarcian. Scale bar = 99 μm.

4. ***Jacus*** (?) species A 34

Maude Formation. loc. QC-622; upper Pliensbachian; ?lower Toarcian. Scale bar = 84 μm.

5, 12, 13. ***Napora insolita***, new species 41

5. Paratype (Pessagno Collection). Warm Springs Member, Snowshoe Formation. loc. OR-589; upper Toarcian. Scale bar = 99 μm.

12, 13. Holotype (USNM 379333). Warm Springs Member, Snowshoe Formation. loc. OR-589; upper Toarcian. Scale bar = 84 and 60 μm, respectively.

6, 14. ***Jacus reiferensis***, new species 32

Paratype (Pessagno Collection). Sandstone member, San Hipólito Formation. loc. BPW-30; upper Pliensbachian; ?Toarcian. Scale bar = 87 and 40 μm, respectively.

7, 10. ***Farcus*** (?) species C 24

Sandstone member, San Hipólito Formation. loc. BPW-30; upper Pliensbachian; ?Toarcian. Scale bar = 87 and 61.2 μm, respectively.

8, 15. ***Napora mitrata***, new species 42

Holotype (USNM 379339). Hyde Formation. loc. OR-600; upper Pliensbachian?; lower Toarcian; ?upper Toarcian. Scale bar = 120 and 54 μm, respectively.

9. ***Jacus*** (?) species B 34

Warm Springs Member, Snowshoe Formation. loc. OR-589; upper Toarcian. Scale bar = 75 μm.

EXPLANATION OF PLATE 6

All figures are scanning electron micrographs of ultranaporid Nassellariina from the Middle Jurassic (Aalenian? and lower Bajocian) Snowshoe Formation, Grant County, east-central Oregon. Scale bar (upper right) is used as a reference for the magnification of all figures.

Figure — Page

1–3. ***Napora fructuosa***, new species 39
Warm Springs Member, Snowshoe Formation. This species is also known from the Lower Jurassic (upper Toarcian).
1. Holotype (USNM 379325). loc. OR-593; ?Aalenian. Scale bar = 109 μm.
2, 3. Paratypes (Pessagno Collection). loc. OR-593; ?Aalenian. Scale bar = 120 and 99 μm, respectively.

4, 5. ***Napora bona***, new species 36
Warm Springs Member, Snowshoe Formation.
4. Holotype (USNM 379302). loc. OR-580; ?Aalenian. Scale bar = 75 μm.
5. Topotype (destroyed in SEM work). loc. OR-580; ?Aalenian. Arrow points to cephalocone. Cephalis is quite large. Scale bar = 75 μm.

6, 7. ***Napora browni***, new species 36
Warm Springs Member, Snowshoe Formation.
6. Holotype (USNM 379306). loc. OR-580; ?Aalenian. Arrow points to cephalocone. Cephalis is quite large. Scale bar = 99 μm.
7. Paratype (Pessagno Collection). loc. OR-580; ?Aalenian. Arrow points to cephalocone. Note large cephalis and asymmetrical horn. Scale bar = 109 μm.

8. ***Napora*** species aff. ***N. cosmica***, new species 39
Warm Springs Member, Snowshoe Formation. loc. OR-580; ?Aalenian. Scale bar = 99 μm.

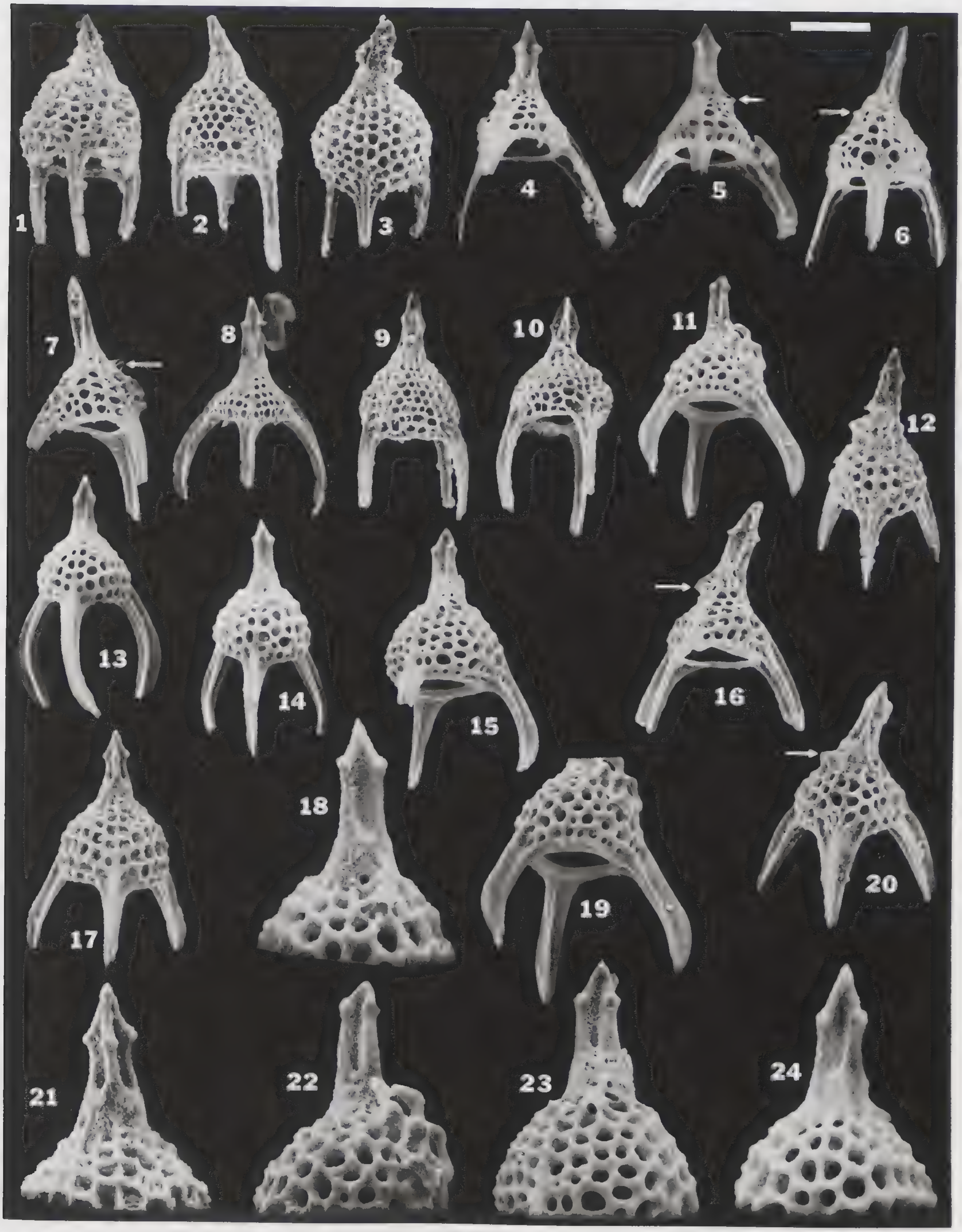
9, 10. ***Napora turgida***, new species 45
Warm Springs Member, Snowshoe Formation. This species differs from *N. fructuosa*, n. sp., by having a longer horn with wider grooves and a smaller cephalis.
9. Holotype (USNM 379349). loc. OR-555; lower Bajocian. Scale bar = 120 μm.
10. Paratype (Pessagno Collection). loc. OR-555; lower Bajocian. Scale bar = 120 μm.

11, 13, 15, 19, 22–24. ***Napora baumgartneri***, new species 35
11, 19, 22. Holotype (USNM 379298). Warm Springs Member, Snowshoe Formation. loc. OR-554; lower Bajocian. Scale bar = 84, 66, and 42 μm, respectively.
13, 24. Figured Specimen. Warm Springs Member, Snowshoe Formation. loc. OR-594; lower Bajocian. Scale bar = 99 and 45 μm, respectively.
15, 23. Paratype (Pessagno Collection). Warm Springs Member, Snowshoe Formation. loc. OR-554; lower Bajocian. Scale bar = 108 and 48 μm, respectively.

12. ***Napora*** species D 46
Warm Springs Member, Snowshoe Formation; loc. OR-593; ?Aalenian. Scale bar = 99 μm.

14, 17, 18, 21. ***Napora opaca***, new species 44
Warm Springs Member, Snowshoe Formation.
14, 18. Holotype (USNM 379345). loc. OR-594; lower Bajocian. Scale bar = 99 and 45 μm, respectively.
17, 21. Paratype (Pessagno Collection). loc. OR-594; lower Bajocian. Scale bar = 99 and 48 μm, respectively.

16, 20. ***Napora horrida***, new species 40
Warm Springs Member, Snowshoe Formation.
16. Paratype (Pessagno Collection). loc. OR-555; lower Bajocian. Arrow points to massive cephalocone. Scale bar = 99 μm.
20. Holotype (USNM 379331). loc. OR-555; lower Bajocian. Arrow points to massive cephalocone. Note large cephalis and massive, asymmetrically-placed horn. Scale bar = 84 μm.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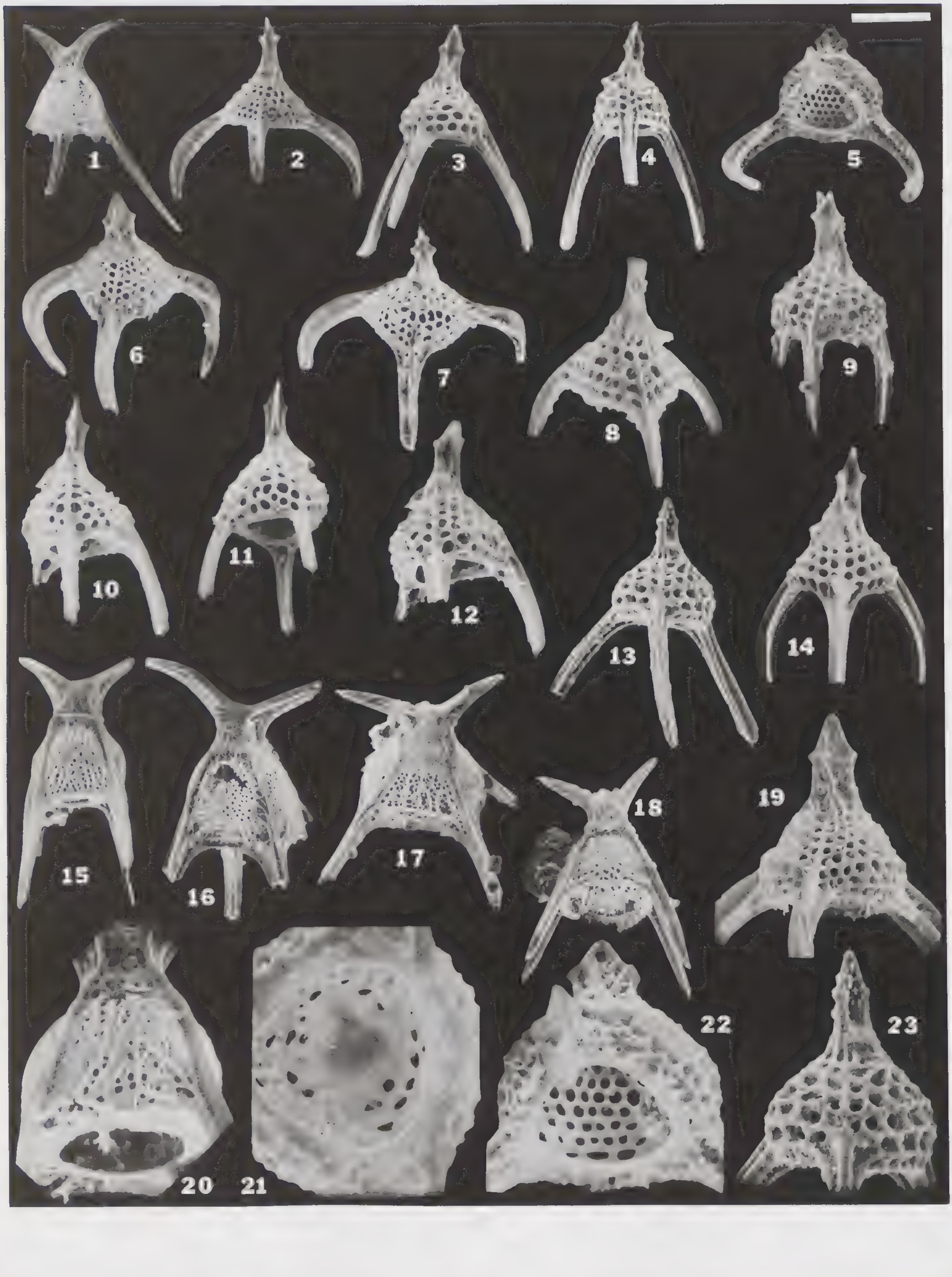
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EXPLANATION OF PLATE 7

All figures are scanning electron micrographs of Middle Jurassic ultranaporid and hilarisiregid Nassellariina from the Snowshoe Formation, Grant County, east-central Oregon. Scale bar (upper right) is used as a reference for the magnification of all figures.

Figure — Page

1, 20. ***Hilarisirex*** species A 31
Warm Springs Member, Snowshoe Formation, near Izee. loc. OR-594; lower Bajocian. Note outer latticed layer of vermicular ridges. Scale bar = 150 and 54 μm, respectively.

2, 5–7, 19, 21, 22. ***Napora cosmica,*** new species 38
South Fork Member, Snowshoe Formation.
2, 7. Holotype (USNM 379323). loc. OR-513; upper Bajocian. Scale bar = 69 and 84 μm, respectively.
5, 6, 19, 22. Paratype (Pessagno Collection). loc. OR-513; upper Bajocian. Scale bar = 84, 84, 60, and 40 μm, respectively.
21. Paratype (Pessagno Collection). loc. OR-513; upper Bajocian. Scale bar = 30 μm.

3, 4, 13, 23. ***Napora maritima,*** new species 42
Warm Springs Member, Snowshoe Formation.
3, 4. Paratypes (Pessagno Collection). loc. OR-555; lower Bajocian. Scale bar = 109 and 171 μm, respectively.
13, 23. Holotype (USNM 379337). loc. OR-555; lower Bajocian. Note long, straight feet, which distinguish this species from *N. baumgartneri,* n. sp. (see Pl. 6, fig. 11) and *N. opaca,* n. sp. (see Pl. 6, fig. 14). Scale bar = 99 and 60 μm, respectively.

8. ***Napora*** species B 46
Lower part of Warm Springs Member, Snowshoe Formation. loc. OR-516; lower Bajocian. Scale bar = 48 μm.

9. ***Napora*** species H 46
Snowshoe Formation (undifferentiated), exposed near Seneca. loc. OR-550C; upper Bajocian. Scale bar = 60 μm.

10–12. ***Napora bearensis,*** new species 35
Snowshoe Formation (undifferentiated) exposed near Seneca.
10, 12. Paratypes (Pessagno Collection). loc. OR-549B; upper Bajocian. Scale bar = 99 and 99 μm, respectively.
11. Holotype (USNM 379300). Note large cephalocone. loc. OR-549B; upper Bajocian. Scale bar = 99 μm.

14. ***Napora*** species A 46
Warm Springs Member, Snowshoe Formation. loc. OR-554; lower Bajocian. Scale bar = 60 μm.

15. ***Hilarisirex*** species C 32
Snowshoe Formation (undifferentiated) exposed near Seneca. loc. OR-549B; upper Bajocian. Scale bar = 99 μm.

16. ***Hilarisirex*** species B 32
Warm Springs Member, Snowshoe Formation. loc. OR-554; lower Bajocian. Scale bar = 75 μm.

17, 18. ***Hilarisirex oregonensis,*** new species 31
South Fork Member, Snowshoe Formation exposed near Izee (see also Pl. 8).
17. Holotype (USNM 379290). loc. OR-501B; upper Bathonian. Note inner latticed layer of flattened polygonal pore frames and outer latticed layer of vermicular ridges comprising abdominal wall. Scale bar = 84 μm.
18. Paratype (Pessagno Collection). loc. OR-501B. Note that outer latticed layer of vermicular ridges is more highly-developed on this specimen than on the holotype (Pl. 7, fig. 17). Scale bar = 99 μm.

EXPLANATION OF PLATE 8

All figures are scanning electron micrographs of Middle Jurassic (upper Bathonian) ultranaporid and hilarisiregid Nassellariina. Scale bar (upper right) is used as a reference for the magnification of all figures.

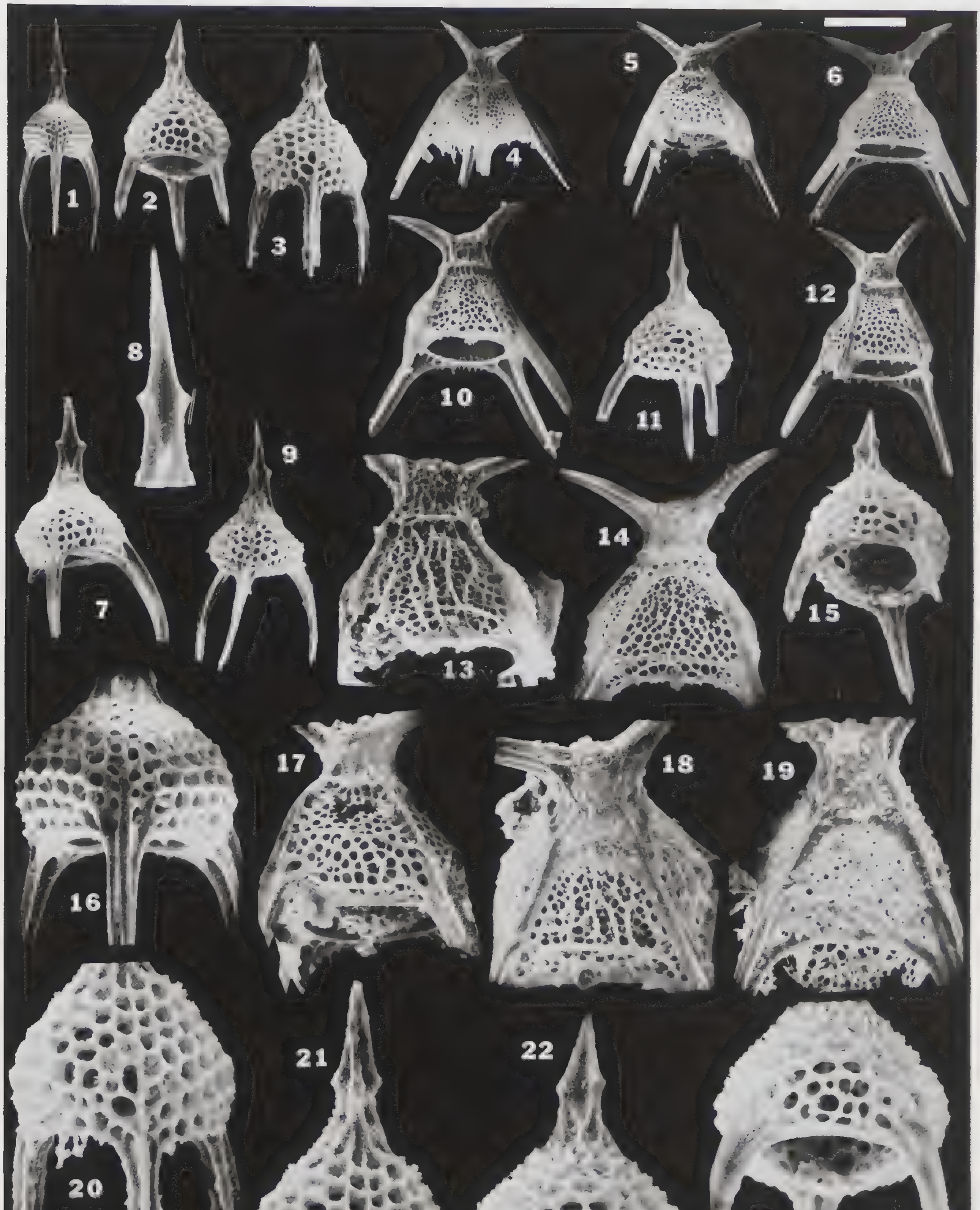
Figure — Page

1, 7–9, 11, 16. ***Napora izeensis***, new species 41
South Fork Member, Snowshoe Formation, near Izee, Grant County, Oregon.
1, 8, 16. Holotype (USNM 379335). loc. OR-501B; upper Bathonian. Scale bar = 171, 54, and 54 μm, respectively.
7. Paratype (Pessagno Collection). loc. OR-501B; upper Bathonian. Scale = 132 μm.
9. Paratype (Pessagno Collection). loc. OR-501B; upper Bathonian. Scale bar = 150 μm.
11. Paratype (Pessagno Collection). loc. OR-501B; upper Bathonian. Scale bar = 99 μm.

2, 3, 15, 20–23. ***Napora antelopensis***, new species 34
South Fork Member, Snowshoe Formation, near Izee, Grant County, Oregon.
2, 15, 22, 23. Holotype (USNM 379296). loc. OR-501B; upper Bathonian. Scale bar = 99, 75, 48, and 48 μm, respectively.
3, 20, 21. Paratype (Pessagno Collection). loc. OR-501B; upper Bathonian. Scale bar = 99, 48, and 48 μm, respectively.

4–6, 10, 13, 14, 17. ***Hilarisirex inflatus***, new species 30
South Fork Member, Snowshoe Formation, near Izee, Grant County, Oregon.
4, 5, 17. Holotype (USNM 379288). loc. OR-501B; upper Bathonian. Scale bar = 99, 109, and 48 μm, respectively.
6, 14. Topotype. loc. OR-501B; upper Bathonian. Specimen destroyed during SEM work. On abdomen, note flattened pore frames comprising inner latticed layer and weakly-developed vermicular outer latticed layer. Scale bar = 99 and 60 μm, respectively.
10, 13. Paratypes (Pessagno Collection). loc. OR-501B; upper Bathonian. See comments on morphology for figures 6 and 14 above. Scale bar = 84 and 48 μm, respectively.

12, 18, 19. ***Hilarisirex oregonensis***, new species 31
South Fork Member, Snowshoe Formation, near Izee, Grant County, Oregon.
12. Paratype (Pessagno Collection). loc. OR-501B; upper Bathonian. Scale bar = 84 μm.
18. Holotype (USNM 379290). loc. OR-501B; upper Bathonian (see also Pl. 7, fig. 17). Scale bar = 48 μm.
19. Paratype (Pessagno Collection). loc. OR-501B; upper Bathonian (see also Pl. 7, fig. 18). Scale bar = 48 μm.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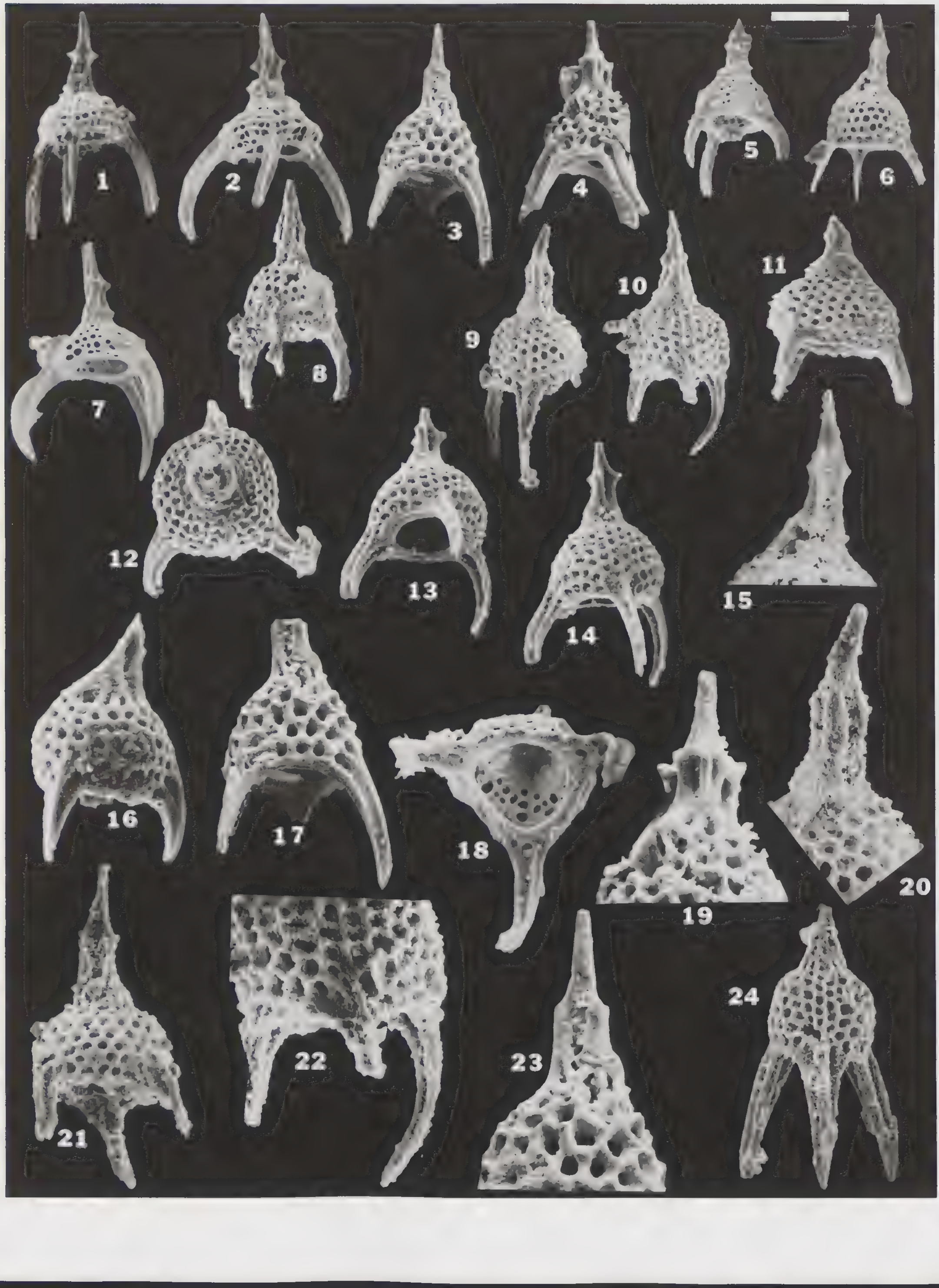
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EXPLANATION OF PLATE 9

All figures are scanning electron micrographs of Middle Jurassic ultranaporid Nassellariina from Oregon and Upper Jurassic ultranaporid Nassellariina from California and Mexico. Scale bar (upper right) is used as a reference for the magnification of all figures.

Figure — Page

1, 2, 7, 18. ***Napora tumultuosa***, new species 44
South Fork Member, Snowshoe Formation, near Izee, Grant County, Oregon. Middle Jurassic.
1. Paratype (Pessagno Collection). loc. OR-501B; upper Bathonian. Scale bar = 133 μm.
2. Holotype (USNM 379347). loc. OR-501B; upper Bathonian. Scale bar = 120 μm.
7, 18. Paratype (Pessagno Collection). loc. OR-501B; Upper Bathonian. Note flattened pore frames on thoracic interior. Scale bar = 99 and 66 μm, respectively.

3, 4, 17, 19, 23. ***Napora boneti***, new species 36
Lower member of type Taman Formation west of Tamazunchale, San Luis Potosí, Mexico. Upper Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984).
3, 17, 23. Holotype (USNM 379304). loc. MX-82-15; upper Kimmeridgian. Note distinctive horn. Specimen replaced by limonite. Scale bar = 100, 58.8, and 37.5 μm, respectively.
4, 19. Paratype (Pessagno Collection). Specimen replaced by limonite. Scale bar = 100 and 37.5 μm, respectively.

5, 12–14. ***Napora bukryi*** Pessagno, 1977a 37
Volcanogenic–pelagic strata overlying Coast Range ophiolite at Point Sal, Santa Barbara County, California. Upper Jurassic.
5. Holotype (USNM 22002). loc. NSF-907; upper Kimmeridgian. Note figured specimen is foreshortened due to tilting. Thorax normally appears more hemispherical in character. Scale bar = 60 μm.
12. Figured specimen. loc. NSF-908; lower Tithonian; Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984). C (arrow) marks cephalocone. Scale bar = 60 μm.
13, 14. Topotype. loc. NSF-907; upper Kimmeridgian; upper Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984). Scale bar = 99 and 99 μm, respectively.

6, 15. *Napora* species aff. ***N. moctezumaensis***, new species 43
Lower member of type Taman Formation west of Tamazunchale, San Luis Potosí, Mexico. loc. MX-82-8. Upper Jurassic (lower part of upper Kimmeridgian). Lower Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984). Scale bar = 85.5 and 37.5 μm, respectively.

8–10, 20–22. ***Napora moctezumaensis***, new species 43
Lower member of type Taman Formation west of Tamazunchale, San Luis Potosí, Mexico. Upper Jurassic. Lower part of Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984).
8. Paratype (Pessagno Collection). loc. MX-82-8; lower part of upper Kimmeridgian. Note slender feet and distinctive horn (Pl. 9, figs. 20, 21). Scale bar = 85.5 μm.
9, 20. Paratype (Pessagno Collection). loc. MX-82-8. Scale bar = 85.5 and 37.5 μm, respectively.
10, 22. Holotype (USNM 379341). loc. MX-82-8; upper Kimmeridgian. Scale bar = 85.5 and 37.5 μm, respectively.
21. Paratype (Pessagno Collection). loc. MX-82-8; lower part of upper Kimmeridgian. Scale bar = 58.8 μm.

11, 16. ***Napora lospensis*** Pessagno 42
Volcanogenic–pelagic strata overlying Coast Range ophiolite at Point Sal, Santa Barbara County, California. Upper Jurassic. Upper Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984).
11. Holotype (USNM 22004). loc. NSF-907. Note broad thorax, massive pore frames, massive short horn, and massive short feet; feet broken. Scale bar = 60 μm.
16. Topotype. Pore frames more massive and less numerous than those of holotype. loc. NSF-907; upper Kimmeridgian. Scale bar = 48 μm.

24. ***Napora vegaensis***, new species 45
Lower member of type Taman Formation west of Tamazunchale, San Luis Potosí, Mexico. Upper Jurassic. Lower Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984). Holotype (USNM 379351). loc. MX-82-8; upper Kimmeridgian. Note long, massive, straight feet, and short, massive horn. Scale bar = 85.5 μm.

EXPLANATION OF PLATE 10

All figures are scanning electron micrographs of Upper Jurassic (upper Kimmeridgian to upper Tithonian) hilarisiregid and ultranaporid Nassellariina from California and east-central Mexico. Scale bar (upper right) is used as a reference for the magnification of all figures.

Figure — Page

1. ***Hilarisirex*** species D 32
Volcanogenic–pelagic strata overlying Coast Range ophiolite at Point Sal, Santa Barbara County, California. loc. NSF-907; upper Kimmeridgian. Scale bar = 150 μm.

2–5, 15, 16, 21–23. ***Napora burckhardti,*** new species 37
Lower member of type Taman Formation west of Tamazunchale, San Luis Potosí, Mexico. Upper Jurassic (lower Tithonian). Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984).
2, 3, 15, 21. Holotype (USNM 379308). loc. MX-81-54. Note distinctive horn and long, slender feet. Specimen replaced by pyrite. Scale bar = 99, 99, 33, and 42 μm, respectively.
4, 16, 22. Paratype (Pessagno Collection). loc. MX-81-54. Specimen replaced by pyrite. Scale bar = 99, 48, and 48 μm, respectively.
5. Paratype (Pessagno Collection). loc. MX-81-54. Specimen replaced by pyrite. Scale bar = 99 μm.
23. Paratype (Pessagno Collection). loc. MX-81-54. Cephalic wall and upper part of thoracic wall broken away. C marks hemispherical cephalis. Scale bar = 45 μm.

6. ***Napora*** species C 46
Volcanogenic–pelagic strata overlying Coast Range ophiolite at Point Sal, Santa Barbara County, California. loc. NSF-907; upper Kimmeridgian). Upper part of Zone 2 (*sensu* Pessagno, Blome, and Longoria, 1984). Scale bar = 120 μm.

7. ***Napora*** species G 46
Lower member of type Taman Formation west of Tamazunchale, San Luis Potosí, Mexico. loc. MX-81-54; lower Tithonian. Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984). Specimen replaced by pyrite. Scale bar = 99 μm.

8, 10–12, 17, 20, 24. ***Napora heimi,*** new species 40
Lower member of type Taman Formation west of Tamazunchale, San Luis Potosí, Mexico. Upper Jurassic (lower Tithonian). Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984).
8, 20, 24. Holotype (USNM 379329). loc. MX-81-54. Note massive horn with large, lenticular grooves between massive, rounded ridges. Specimen replaced by pyrite. Scale bar = 84, 42, and 42 μm, respectively.
10. Paratype (Pessagno Collection). loc. MX-81-54. Specimen replaced by pyrite. Scale bar = 84 μm.
11. Figured specimen. loc. MX-82-20; replaced by pyrite. Scale bar = 85.5 μm.
12, 17. Figured specimen. loc. MX-82-20. Specimen replaced by pyrite. Note structure of horn. Scale bar = 85.5 and 37.5 μm, respectively.

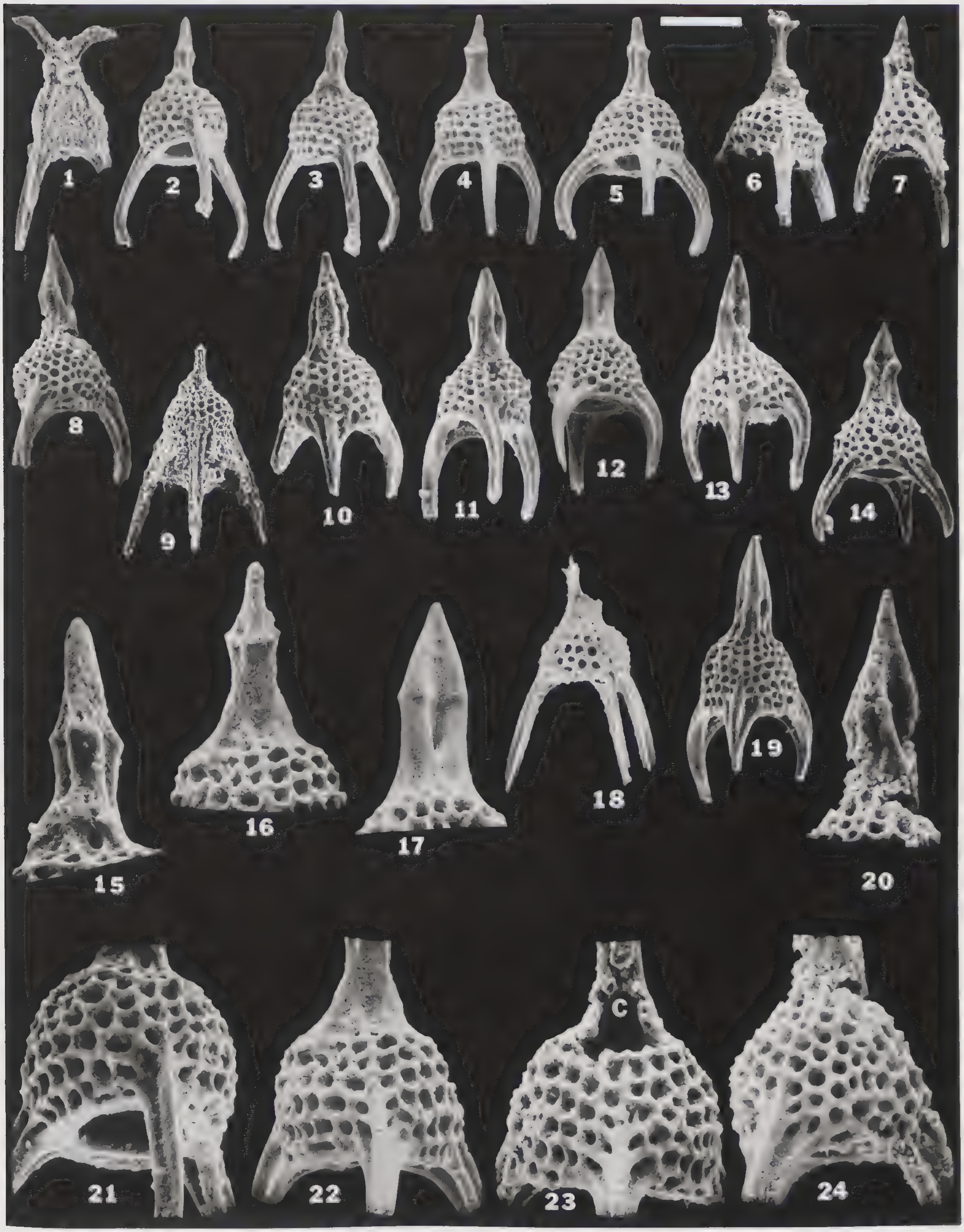
9. ***Napora*** species F 46
Upper member of type Taman Formation near village of Taman, San Luis Potosí, Mexico. loc. MX-82-37. Upper Jurassic (lower part of upper Tithonian); lower Zone 4 (*sensu* Pessagno, Blome, and Longoria, 1984). Scale bar = 142 μm.

13. ***Napora*** species aff. ***N. heimi,*** new species 40
Lower member of type Taman Formation west of Tamazunchale, San Luis Potosí, Mexico. loc. MX-81-54. Upper Jurassic (lower Tithonian). Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984). Specimen replaced by pyrite. Scale bar = 84 μm.

14. ***Napora deweveri*** Baumgartner, *sensu lato* 39
Lower member of type Taman Formation west of Tamazunchale, San Luis Potosí, Mexico. loc. MX-81-54. Upper Jurassic (lower Tithonian). Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984). Specimen replaced by pyrite. This form differs from *N. deweveri s.s.* by having larger, less numerous pore frames and a more hemispherical thorax. Scale bar = 84 μm.

18. ***Napora*** species E 46
Upper member of type Taman Formation near village of Taman, San Luis Potosí, Mexico. loc. MX-82-37. Upper Jurassic (lower part of upper Tithonian). Lowermost Zone 4 (*sensu* Pessagno, Blome, and Longoria, 1984). Scale bar = 85.5 μm.

19. ***Napora*** species aff. ***N. deweveri*** Baumgartner 39
Lower member of type Taman Formation west of Tamazunchale, San Luis Potosí, Mexico. loc. MX-82-20. Upper Jurassic (lower Tithonian). Zone 3 (*sensu* Pessagno, Blome, and Longoria, 1984). Specimen replaced by pyrite. This form differs from *N. deweveri s.s.* by having a horn with large, lenticular, open grooves. It does possess a subcylindrical thorax with numerous pore frames. Scale bar = 85.5 μm.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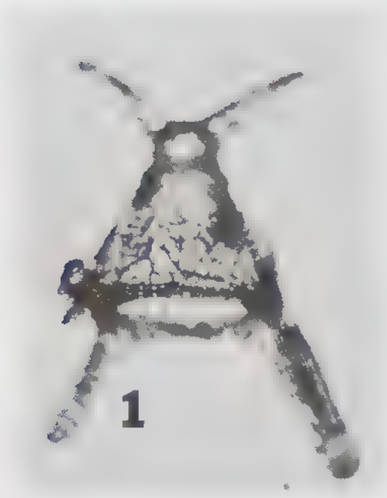
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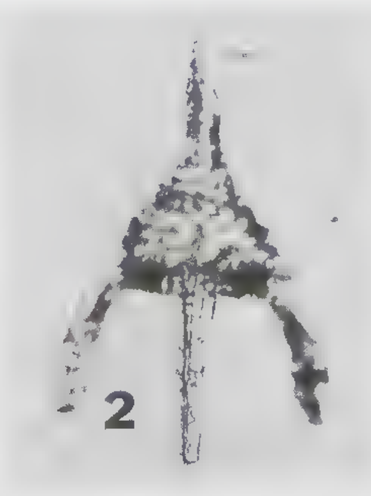
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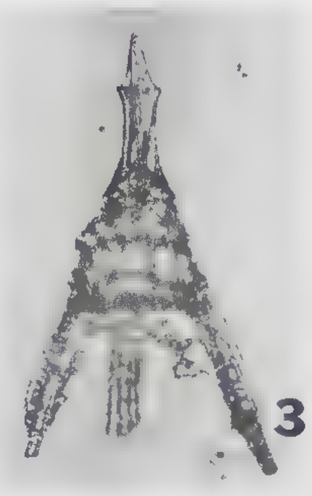
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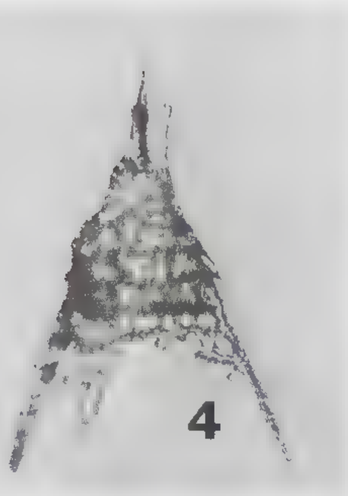
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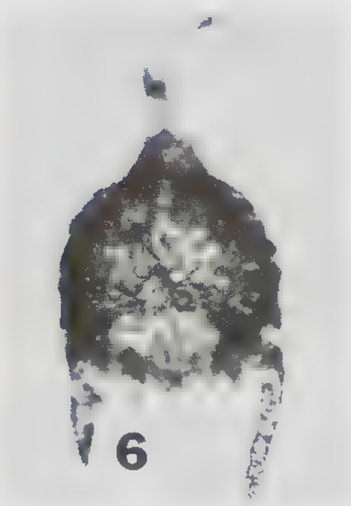
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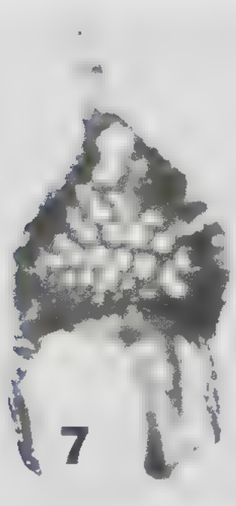
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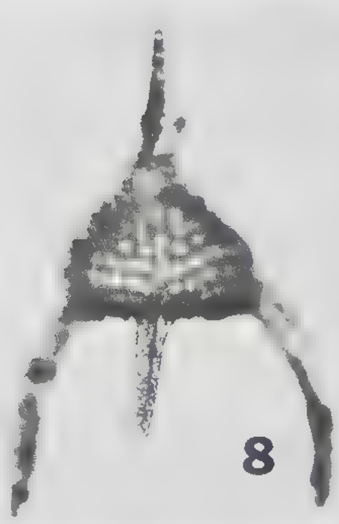
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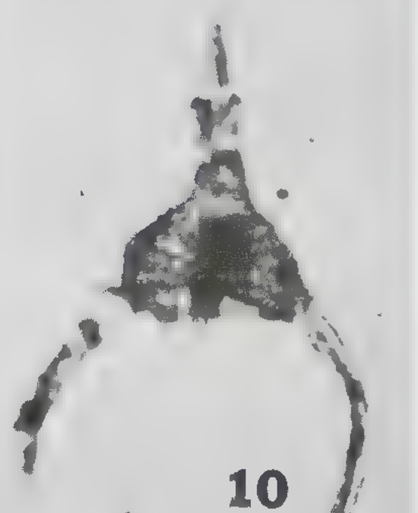
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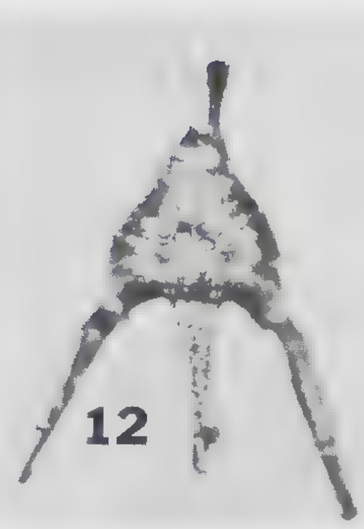
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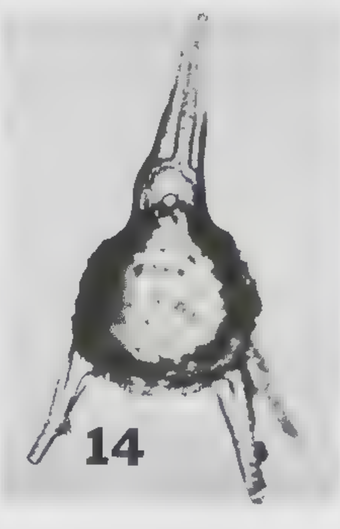
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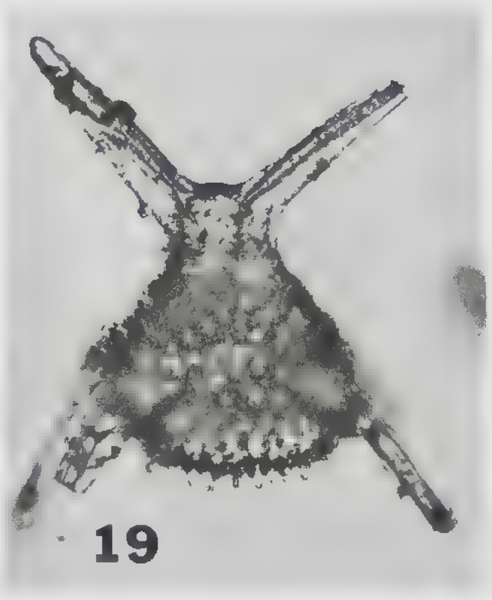
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EXPLANATION OF PLATE 11

All figures are transmitted light photomicrographs of Jurassic Nassellariina. The preservation of most of the Radiolaria was not conducive to transmitted-light microscopy. As a result, only a few taxa could be illustrated using transmitted light photomicrographs.

Figure — Page

1. ***Hilarisirex inflatus***, new species 30
Paratype (USNM 379289). loc. OR-501B. South Fork Member, Snowshoe Formation, east-central Oregon. Middle Jurassic (upper Bathonian). Width of A-frame (base of abdomen) = 110 μm.

2. ***Napora maritima***, new species 42
Paratype (USNM 379338). loc. OR-555. Warm Springs Member, Snowshoe Formation, east-central Oregon. Middle Jurassic (lower Bajocian). Length of horn = 60 μm.

3, 4. ***Napora*** (?) ***graybayensis***, new species 39
Paratype (USNM 379328). loc. QC-675. Middle black argillite member, Kunga Formation, Queen Charlotte Islands, B.C. Lower Jurassic (upper Sinemurian). Length of horn of specimen in figure 3 = 60 μm; length of horn in specimen in figure 4 = 60 μm.

5. ***Napora horrida***, new species 40
Paratype (USNM 379332). loc. OR-555. Warm Springs Member, Snowshoe Formation, east-central Oregon. Middle Jurassic (lower Bajocian). Length of foot (right) = 100 μm.

6. ***Napora fructuosa***, new species 39
Paratype (USNM 379326). loc. OR-593. Warm Springs Member, Snowshoe Formation, east-central Oregon. Middle Jurassic (Aalenian?). Length of horn = 48 μm.

7. ***Napora bearensis***, new species 35
Paratype (USNM 379301). loc. OR-549B. Snowshoe Formation, east-central Oregon. Middle Jurassic (upper Bajocian). Length of horn = 50 μm.

8. ***Napora izeensis***, new species 41
Paratype (USNM 379336). loc. OR-501B. South Fork Member, Snowshoe Formation, east-central Oregon. Middle Jurassic (upper Bathonian). Length of horn = 90 μm.

9. ***Farcus asperoensis***, new species 23
Paratype (USNM 379277). loc. SH-412-14. Sandstone member, San Hipolito Formation, Baja California Sur, Mexico. Lower Jurassic (upper Pliensbachian; Toarcian?). Length of horn = 66 μm.

10. ***Napora cosmica***, new species 38
Paratype (USNM 379324). loc. OR-513. South Fork Member, Snowshoe Formation, east-central Oregon. Middle Jurassic (upper Bajocian). Length of horn = 80 μm.

11, 12. ***Napora mitrata***, new species 42
Paratype (USNM 379340). loc. OR-600. Hyde Formation, east-central Oregon. Lower Jurassic (upper Pliensbachian?; lower Toarcian; upper Pliensbachian?). Same specimen viewed at different focal planes. Length of horn = 60 μm.

13. ***Jacus*** (?) ***sandspitensis***, new species 33
Paratype (USNM 379295). loc. QC-534. Maude Formation, Queen Charlotte Islands, B.C. Lower Jurassic (lower Pliensbachian). Length of horn = 55 μm.

14. ***Farcus*** species 22
Hyde Formation, east-central Oregon. Lower Jurassic (upper Pliensbachian?; lower Toarcian; upper Toarcian?). Length of horn = 90 μm.

15. ***Rolumbus mirus***, new species 28
Paratype (USNM 379285). loc. OR-600. Hyde Formation, east-central Oregon. Lower Jurassic (upper Pliensbachian?; lower Toarcian; upper Toarcian?). Longer horn = 95 μm.

16. ***Napora vegaensis***, new species 45
Paratype (USNM 379352). loc. MX-82-8. Taman Formation, east-central Mexico. Upper Jurassic (Kimmeridgian). Length of horn = 45 μm.

17. ***Napora turgida***, new species 45
Paratype (USNM 379350). loc. OR-555. Warm Springs Member, Snowshoe Formation, east-central Oregon. Middle Jurassic (lower Bajocian). Length of horn = 55 μm.

18. ***Napora antelopensis***, new species 34
Paratype (USNM 379297). loc. OR-501B. South Fork Member, Snowshoe Formation, east-central Oregon. Middle Jurassic (upper Bathonian). Length of horn = 70 μm.

19. ***Rolumbus mirus***, new species 28
Paratype (USNM 379285). loc. OR-600. Hyde Formation, east-central Oregon. Lower Jurassic (upper Pliensbachian?; lower Toarcian; upper Toarcian?). Longer horn = 100 μm.

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  Menlo Park, CA 50
  Mesozoic locality
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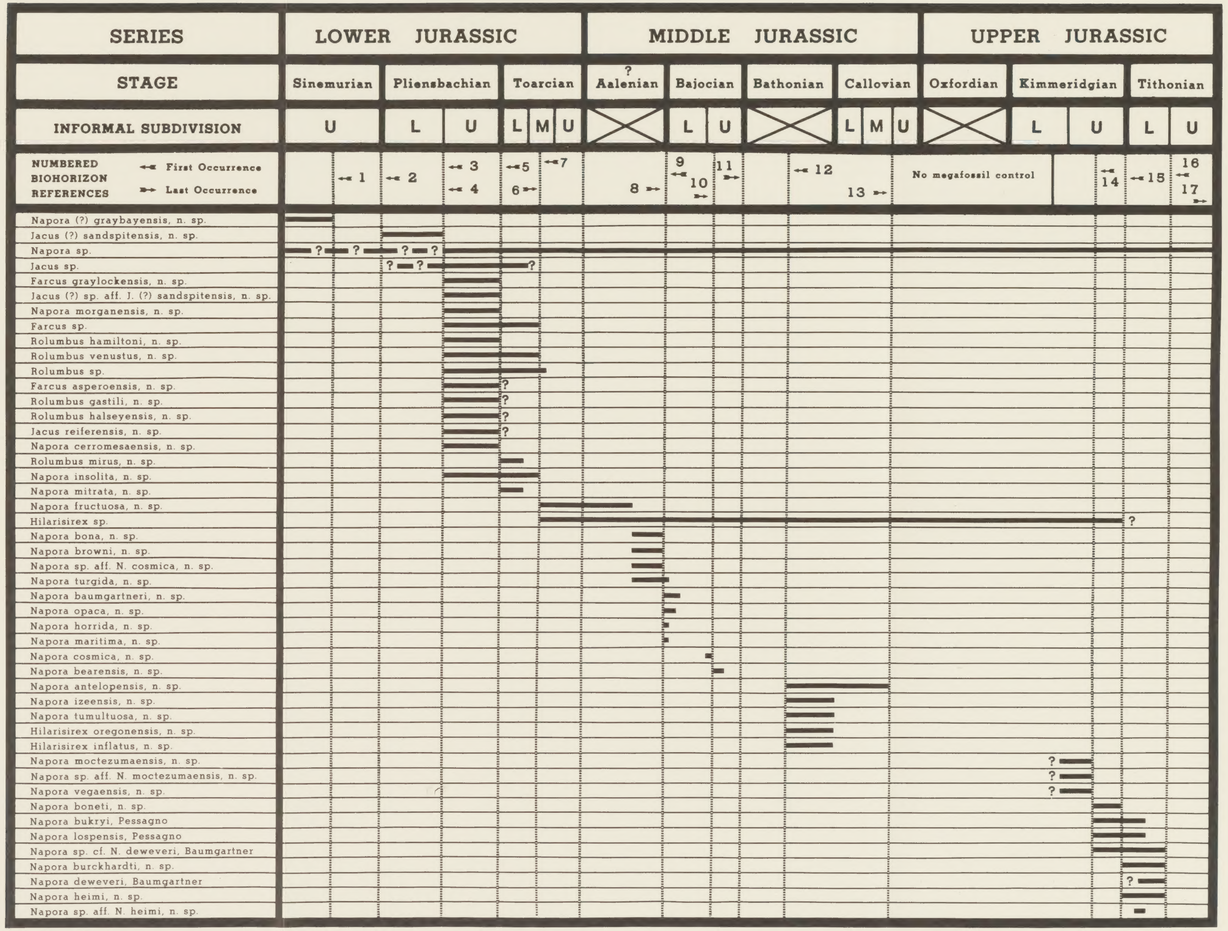
Text-figure 7.—Range zones of Lower, Middle, and Upper Jurassic species assignable to Farcidae Pessagno, Whalen, and Yeh, n. fam., Ultranaporidae Pessagno, 1977b, and Hilarisiregidae Takemura and Nakaseko, 1982. **L** = Lower; **M** = Middle; and **U** = Upper. Numbered biohorizons (broken vertical lines) used for biostratigraphic and chronostratigraphic reference (see below).

1. *Canutus* Pessagno and Whalen, 1982.
2. *Canutus tipperi* Pessagno and Whalen, 1982.
3. *Canoptum anulatum* Pessagno and Poisson, 1981. The biohorizon defined by the first occurrence of *C. anulatum* may occur in the upper part of lower Pliensbachian (see discussion in *Appendix*: California Coast Ranges; Lower Jurassic locs. NSF–958, NSF–959, NSF–960).
4. *Trillus elkhornensis* Pessagno and Blome, 1980.
5. *Turanta* Pessagno and Blome, 1982.
6. *Praeconocaryomma parvimamma* Pessagno and Poisson, 1981.
7. *Perispyridium* Dumitrica, 1978 (see discussion in *Appendix*: east-central Oregon; Middle Jurassic loc. OR-593).
8. *Turanta morinae* Pessagno and Blome, 1982 (see discussion in *Appendix*: east-central Oregon; Middle Jurassic loc. OR-580).
9. *Turanta barbara* Pessagno and Blome, 1982 (see discussion in *Appendix*: east-central Oregon; Middle Jurassic loc. OR–555).
10. *Zartus imlayi* Pessagno and Blome, 1980 (see discussion in *Appendix*: east-central Oregon; Middle Jurassic loc. OR-513).
11. *Perispyridium dumitricai* Pessagno and Blome, 1982.
12. *Tripocyclia* Haeckel, 1881 (see Pessagno, 1977a). This taxon is important because it occurs both in the Tethyan and Boreal Realms.
13. *Perispyridium nitidum* Pessagno and Blome, 1982.
14. *Parvicingula* Pessagno (1977a) *sensu stricto*. *Parvicingula s. s.* includes forms like *P. santabarbaraensis* Pessagno, 1977a, which possess a long, slender tube on the final post-abdominal chamber.
15. *Ristola hsui* (Pessagno, 1977a).
16. *Vallupus hopsoni* Pessagno and Blome *in* Pessagno, Blome, and Longoria, 1984.
17. *Ristola altissima* (Rüst, 1885).



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Authors are requested to enclose $10 with each manuscript submitted, to cover costs of postage during the review process.

Collinson, J.
1962. *Size of lettering for text-figures.* Journal of Paleontology, vol. 36, p. 1402.

Gilbert Dennison Harris
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